EFFECT OF SELECTED FABRIC SOFTENERS ON THE SURFACE APPEARANCE AND PHYSICAL PROPERTIES OF COTTON WASH-WEAR FABRICS

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by

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CHAPTER I

INTRODUCTION

With the advent of synthetic fibers there was a decrease in the consumption of cotton fabrics. Cotton manufacturers, perceiving a decline in the use of cotton, attempted to find new ways to produce fabrics with as desirable crease and wrinkle resistant properties as those found in fabrics produced with synthetic fibers. After extensive research, synthetic finishing resins were produced to fulfill partially the desired requirements. These resins caused fabrics to lose their pliability, softness and strength. As early as the 1930's the textile industry began using cationic fabric softeners to increase the pliability and strength of fabrics with resin finishes applied to them; however, the effectiveness of these softeners was lost after several washings.

Fabric softeners are no longer limited to industrial use. The consumer may purchase fabric softeners on the retail market to maintain the desired softness in garments and household products. Fabric softeners have been on the retail market for about seven years, but only recently have large producers of softeners been promoting their products with nationwide advertising campaigns. The consumer purchasing a fabric softener will find a number of different brands from which to choose. With this variety, some confusion may exist as to which product is most suitable for the desired results.

The purpose of this thesis was to study four fabric softeners available for consumer use. The two major objectives of the study were:

first, to determine the degree of effectiveness of each fabric softener in maintaining the original surface appearance of the selected fabrics; second, to determine any effect of the fabric softeners upon the physical properties of the fabrics such as: stiffness, wrinkle recovery and tearing strength. The null hypotheses established to test these objectives are:

1. There are no differences in surface appearance between the fabrics treated with fabric softeners and those not treated with a softener.

2. There are no differences among fabric softeners in maintaining surface appearance of the fabrics.

3. There are no differences in physical properties between fabrics treated with a fabric softener and those not treated with a softener.

4. There are no differences among the fabric softeners as indicated by the physical properties of the fabrics.

This study was limited to the use of four brands of softeners which were in consumer use in the vicinity of Greensboro, North Carolina. The effectiveness of the softeners was determined by surface appearance evaluations and results of physical testing after the application of the softeners to three fabrics. These fabrics, obtained from one manufacturer, differed in finish. One fabric had no finish other than bleaching, mercerizing and other regular mill finishing treatments. The other two fabrics were finished with two resin treatments currently being applied to wash and wear fabrics. Evaluations of surface appearance and physical properties were made after the first, third, sixth, twelfth, and twenty-fourth launderings.

The remainder of the study is divided into four chapters. Chapter II is the review of literature which includes: (1) the history and definition of wash and wear and the types of wash and wear finishes used,

(2) fabric softeners; their definition, purpose, history, quaternary cationic softeners and consumer use. Chapter III describes the procedure for the selection of fabric softeners, selection and preparation of the fabrics, fabric tests, washing procedure and evaluation of the appearance and the statistical analysis. Chapter IV is the presentation and interpretation of the data found after performance of tests pertinent to the evaluation of the softeners. Chapter V contains the summary and conclusions of the study.

CHAPTER II

REVIEW OF LITERATURE

The "finishing operation" in the textile industry refers to any process applied to greige goods to produce a more desirable product. Finishes referred to as "additive finishes" are those applied to the fabric or chemically added with the fibers to give the fabric some special effect. Some of these finishes would include water-repellent, flame-resistant, softening and crease-resistant finishes.[1]

RESIN TREATMENTS FOR WASH AND WEAR PROPERTIES

History

Resin treatments were first introduced into the textile industry in the early 1930's to impart wash and wear characteristics including those of improved dimensional stability, wrinkle resistance and "hand" of fabrics.[2] By 1957 two billion yards of cotton were treated with these resins. In 1960 cotton fabrics constituted sixty-three per cent of the wash and wear fabrics sold in the United States. Nearly two billion yards of fabrics were produced with wash and wear finishes and

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[1]Anthony M. Schwartz, James W. Perry, Julian Berch, Surface Active Agents and Detergents Volume II (New York: Interscience Publishers, Inc., 1958), p. 255.

[2]Robert M. Reinhardt, Russell M. H. Kullman, Harry B. Moore and J. David Reid, "Aftermercerization of Wrinkle-Resistant Cottons for Improved Strength and Abrasion Resistance," American Dyestuff Reporter (November 3, 1958), p. 758.

it is estimated that thirty million pounds of finishing chemicals were used.[3]

Definition

"Wash and wear" has many definitions. The American Society for Testing Materials has defined it as:

> A generic term applied to garments which satisfactorily retain their original neat appearance after repeated wear and suitable home laundering with little or no pressing or ironing.[4]

Wrinkle-Resistant Finishes

There are a number of chemical resins used to impart wash and wear properties to fabrics. One of the most important groups are nitrogen bases chemically combined with formaldehyde, known as N-methylol compounds which would include dimethylol urea, dimethylol ethylene urea, triazones, melamine formaldehyde, epoxides, and combinations of each of these finishes.[5] Only the two finishes used in the study are discussed in detail.

Dimethylol ethylene urea (DMEU) is one of the most important of the N-methylol resins. DMEU imparts wrinkle resistant properties to fabrics by means of a cross-linking reaction with the cellulose by

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[3]Francis Burr, "Ironing Out Wash-and-Wear Wrinkles," Chemical Week, (September 23, 1961), p. 47.

[4]American Society for Testing Materials Committee D-13, ASTM Standards on Textile Materials (Philadelphia: American Society for Testing Materials, 1961), ASTM Designation: D 123-60, p. 44.

[5]A. C. Nuessle, "Creaseproofing Agents for Wash-and-Wear Finishing," Textile Industries, (October, 1959), pp. 116-120.

changing the elasticity of the fiber.[6] Fabrics finished with DMEU have a soft "hand," high wrinkle resistance without excessive strength losses and superiority in chlorine resistance; however, such fabrics are subject to acid hydrolysis.

Triazone has been used commercially since early 1950. This cross-linking resin is less susceptible to chlorine damage and acid hydrolysis than is DMEU; for this reason triazone is used more for white fabrics. This finish is susceptible to discoloration and odor formation at high curing temperatures.[7]

Chlorine retention is an important factor in wash and wear finishes.

> The resin treated cotton fabric acquires an ability to pick up chlorine from a hypo-chlorite bleach bath and form chloroamides. The chloroamides are unstable chemical compounds which may decompose at the temperature of ironing with a liberation of traces of hydrochloric acid. It is the release of this acid during ironing that impairs the strength of a bleached, wash/wear fabric.[8]

Because there is a decrease in strength caused by application of resins, surfactants in the form of lubricants, softeners and thermoplastic materials are added to the resin bath to decrease this loss.[9]

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[6]J. G. Frick, Jr., B. A. Kottes Andrews, and J. David Reid, "Effects of Cross-Linkage in Wrinkle-Resistant Cotton Fabrics," Textile Research Journal, (July, 1960), p. 495.

[7]Burr, op. cit., p. 48; and Sanford P. Young, "A Millman's Guide to Wash-Wear Finishes," Modern Textiles Magazine, (October, 1961), p. 32.

[8]Young, ibid., pp. 32, 57.

[9]Reinhardt, loc. cit.

FABRIC SOFTENERS

Definition and Purpose

Fabric softeners belong to a group of chemicals known as surfactants. This widely accepted word "surfactant" comes from the contraction of the phrase surface active agent.[10]

> Probably the best definition for surfactants is that of water-soluble compounds which in moderate concentrations, for instance, in a 1% solution, reduce the surface tension of water to half or less of its original value. Since the surface of pure water is approximately 72 dynes per cm, a 1% solution of the surfactant should have a tension of less than 36 dynes . . . . It is obvious that the usual function of a surfactant is to assist in maintaining the surface of interface between two phases, and thus to support wetting, penetrating, foaming, emulsifying, and dispersing.[11]

A surfactant is formed by combining a water-soluble chemical group with an oil-soluble group so that the final product will have surface activity.[12] Some surfactants would include: soaps, detergents, shampoos, water-repellent finishes, softening finishes, and antistatic finishes.

History of Fabric Softeners

The textile industry has been using fabric softeners since the 1930's. They first began using them on rayon fabrics to give them a softer "hand" and better draping qualities.[13] Today in the textile in-

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[10] Schwartz, *op. cit.*, p. 3.

[11] Samuel B. McFarlane (ed.), *Technology of Synthetic Fibers* (New York: Fairchild Publications, Inc., 1953), pp. 298-9.

[12] *Armour Ethoxylated Chemicals*, (Armour Industrial Chemical Company, n.d.), p. 1.

[13] Harold L. Ward, "Textile Softeners for Home Laundering," *Journal of Home Economics*, (February, 1957), p. 122.

dustry four types of fabric softeners are used: (1) anionic; (2) quaternary cationics; (3) non-quaternary cationics; and (4) nonionic compounds. Before these softeners were produced oil and wax emulsions and sulfonated gylceride fats were used as softeners.[14]

Quaternary Cationic Fabric Softeners

Most of the fabric softeners produced for consumer use are of the quaternary cationic type. This review deals with this type only, since the study made was on retail fabric softeners.

These fabric softeners work on the principle that the positively charged portion of the fabric softeners are attracted to the negatively charged fabrics and form a coating on the filaments in the fibers. This lubrication adds softness and allows the fibers to slip over each other thus reducing wear and increasing the life of the fabric.[15]

> The positive portion of the molecule containing the nitrogen and the long fatty hydrocarbon chains attaches itself, by virtue of the cationic properties of the nitrogen, to surfaces which are generally negative by comparison. This attachment is called "substantivity" and is an electrochemical bonding or filming action which holds the high molecular weight cation closely to the individual fibers.[16]

Because of this substantivity the required amount of softener depends on the number of pounds in the wash load rather than on the amount of water in the rinse water.[17]

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[14]Schwartz, op. cit., pp. 262-3.

[15]Technical Data Bulletin, (Texize Chemical, Inc., n.d.), p. 1.

[16]Arquad 2HT Fabric Softener and Conditioner, (Armour Industrial Chemical Company, 1960), p. 2.

[17]"Home Laundry Fabric Softeners," (New York: Jane Ashley Home Service Department Corn Products Company, October, 1957), p. 2.

The benefits derived from using a fabric softener include: softer fabrics, easier ironing, fewer wrinkles, faster drying, sanitizing and anti-static properties.[18]

Fabric Softeners for Consumer Use

Fabric softeners are applied to fabrics by many of the textile manufacturers. After a few launderings they are washed out of the fabric but the consumer can obtain the same effect by use of a commercial fabric softener.[19]

The production of fabric softeners for consumer use is relatively new. In 1955, sales for all brands amounted to half a million dollars.[20] The sale of fabric softeners is growing at a rate of twenty-five per cent a year and it is estimated that by the mid-1960's it will be a fifty million dollar a year business.[21]

All brands of fabric softeners now on the retail market are based on the same general chemical compounds. Most consist of dialkyl quaternary ammonium salts in an alcohol and water solution.

> Typical formula: 75% cationic surface-active agent (usually a quaternary ammonium chloride or sulfate) 18% isopropanol and 7% water. This paste is further diluted with wetting agents (0.5-1%), odorants, tints, bluing, and the like. Active ingredients percentage in the finished softener usually ranges from 3 to 8%.[22]

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[18] Arquad 2HT Fabric Softener and Conditioner, op. cit., pp. 3-4.

[19] Ward, loc. cit.

[20] "Soft Touch is Tough to Sell," Chemical Week, (July 30, 1955), p. 61.

[21] "Sales Spurt Puts New Zip Into Fabric Softeners," Chemical Week, (December 30, 1961), p. 36.

[22] Ward, loc. cit.

The suppliers of raw material are numerous and highly competitive. Some of the main firms selling the basic softener formulation are: Archer-Daniels-Midland Company, Armour Industrial Chemical Company, Foremost Food and Chemical Company, General Mills Chemical Division, and Harshaw Chemical Corporation.[23]

Manufacturers of fabric softeners were confronted with two problems when the market opened. First, fabric softeners required an additional rinse in washing. Manufacturers had to conceive ways to point out to the consumer the benefits and values of this extra step.[24] An additional rinse is required because some soaps and detergents combine with fabric softeners forming an insoluble curd deposited on the fabric.[25] Secondly, the cost was a problem. Since the average cost of a fabric softener was between three and four cents for an average wash load this was not as great a problem as the extra-step.[26]

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[23]"Sales Spurt Puts New Zip Into Fabric Softeners," op. cit., p. 36-7.

[24]"Soft Touch is Tough to Sell," loc. cit.

[25]Technical Data Bulletin, op. cit., p. 2.

[26]"Sales Spurt Puts New Zip Into Fabric Softeners," op. cit., p. 37.

CHAPTER III

PROCEDURE

Selection of Fabric Softeners

The fabric softeners used in the study were brands sold commercially in the vicinity of Greensboro. The four softeners selected were those appearing on the shelves of each of four major chain food stores surveyed (Table I).

TABLE I

SOFTENERS FOUND IN MAJOR CHAIN FOOD STORES

Major Food Stores	Fabric softeners						
	One	Two	Three	Four	Five	Six	Seven
A	X	X	X	X		X	X
B	X	X	X	X	X		
C	X	X	X	X	X	X	
D	X	X	X	X	X		

Selection and Preparation of Fabrics

The fabrics used in this study were given by Dan River Mills, Incorporated of Danville, Virginia. Three twenty-five yard lengths of approximately 85 x 74 print cloth were used for the study. Sample A was treated with a triazone finish, Sample B was treated with DMEU and Sample C was not treated with a resin finish. Each sample was cut into two groups marked as I and II. From these two groups forty squares 16" x 16" were cut and coded, using random sampling. Fifteen of these squares were used for rating surface appearance, the other twenty-five squares were washed and removed for physical testing at predesignated washing intervals.

All the samples in each of the six groups of fabrics were coded to differentiate the control samples and those treated with each of the four softeners.

Fabric Tests

The following measurements were used to indicate the similarities or differences in the fabric construction as influenced by manufacturing procedures.

Fiber length was determined by removing a yarn from the fabric and untwisting until individual fibers could be removed without breaking. These fibers were measured on a slightly oiled metal ruler. Three measurements were taken from both the warp and the filling yarns to obtain a mean length in inches for the fibers used in the warp and filling yarns.

Twist per inch was determined by means of the twist counter manufactured by the United States Testing Company Incorporated. The test procedure followed was that recommended by the American Society for Testing Materials.[1] The test determines the number of turns per inch in the yarn and the direction of the twist. The principle is to remove all the twist from a given length and put the twist back into the yarn until the original length is

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[1]American Society for Testing Materials Committee D-13, ASTM Standards on Textile Materials (Philadelphia: American Society for Testing Materials, 1961), Test Designation: D 1422-59T, pp. 587-9.

obtained. Five tests were made on the warp yarns and five on the filling yarns. The results reported for each direction were a mean of these five tests.

Thread count was determined by the procedure recommended by the American Society for Testing Materials.[2] A micrometer was used to count the warp and filling yarns per square inch. Two counts were made in each direction and an average taken as the final results for warp count and filling count.

Yarn number or the size of the yarns in relation to the weight, was determined by means of the Roller-Smith Universal Yarn Numbering Balance. In this method thirty-six inch lengths of yarn were removed from the fabric weighed on the balance. The means of three tests made on the warp were reported as the yarn number of that direction. The same number of tests were made on the filling yarn.

Weight per square yard was determined by a modification of the method recommended by the American Society for Testing Materials.[3] Three 2 x 2 samples were weighed on a gram balance after drying to remove the moisture. The weight was obtained by using the formula:

$$\text{Oz./sq. yd.} = \frac{\text{Weight of sample in grams}}{\text{Number of square inches}} \times \frac{\text{Sq. inches/sq. yard}}{\text{Grams/ounce}}$$

The mean of the three tests was reported as the ounces per square yard of the fabric.

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[2] Ibid., Test Designation: D 1910-59T Sections 20-23 pp. 823-4.

[3] Ibid., Test Designation: D 1910-59T Sections 25-28, pp. 824-5.

The following tests were made to determine the serviceability of the fabrics. These tests were made on the original fabric and on swatches of the fabric removed after the first, third, sixth, twelfth, and twenty-fourth washing intervals.

<u>Tear resistance</u> was used to determine the mean force required to continue a tear starting from a cut in the fabric. The instrument used was a tear tester of the falling-pendulum type manufactured by Thwing-Albert, Elmendorf Tearing Tester #6-400. The testing procedure followed was that established by the American Society for Testing Materials.[4] The means of five warp and of five filling specimen were reported as the tear resistance in the two directions.

<u>Dimensional change</u> was used as the measure of shrinkage in the warp and filling threads. The test squares were cut and marked with squares measuring fifteen by fifteen inches. Following the launderings, a mean of three measurements was taken and reported as the dimensional change for the warp and filling directions.

<u>Wrinkle recovery</u> tests were made using the method recommended by the American Association of Textile Chemists and Colorists.[5] This test determines the recovery of fabrics from creasing. A sample is creased under controlled conditions of time and weight, allowed to hang in the Monsanto Wrinkle Recovery

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[4]<u>Ibid</u>., Test Designation: D 1424-59, p. 597-601.

[5]William D. Appel, <u>1961 Technical Manual of the American Association of Textile Chemists and Colorists Volume XXXVII</u>. (New York: Howes Publishing Co., Inc., 1961), Tentative Test Method 66-1959T, pp. 155-6.

Tester for a stated period of time before the recovery angle is measured. The means of six samples in the warp direction and of six in the filling direction were totaled and reported as the wrinkle recovery.

Stiffness of the cloth was determined by the cantilever method as recommended by the American Society of Testing Materials.[6] The drape-flex stiffness tester manufactured by Fabric Development Tests was used for the evaluation. The test was employed to determine the drape stiffness which measures how much a fabric drapes under its own weight. The mean of eight tests was reported as the stiffness in inches of overhand in both the warp and filling directions.

Washing Procedure and Evaluation of the Surface Appearance

The test methods for these procedures are based on the test method recommended by the American Association of Textile Chemists and Colorists.[7] The washing machine used was a small size reversing wash wheel type commercial washer manufactured by the American Laundry Machine Industry. A five pound load consisting of test samples plus fabric for extra weight was washed for ten minutes at 140 degrees Fahrenheit with a six inch water level. The samples were given three four-minute rinses using a seven inch water level at 105 degrees Fahrenheit. The fabric softeners were added to the final rinse. The samples were removed from the washer, hung with the warp in a vertical position and allowed to

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[6]American Society for Testing Materials Committee D-13, op. cit., Test Designation: D1388-55T, pp. 581-8.

[7]Appel, op. cit., Tentative Test 88-1961 T pp. 115-118.

drip dry. The pH of the water was checked at predesignated periods by a pH meter manufactured by Analytical Measurements Incorporated.

The purpose of the evaluation of the surface appearance was to determine the retention of the original appearance after specified launderings. The samples were rated under standard lighting conditions and given numerical ratings based on standard plastic replicas manufactured by the Monsanto Chemical Company. A panel of three members evaluated samples from each of the six fabric groups at each testing interval. The fifteen samples in each fabric group evaluated consisted of three control samples (those laundered with no softener) and three laundered using each of the four softeners.

Statistical Analysis

The data from tests of tear resistance, dimensional change, wrinkle recovery and stiffness were analyzed for any significant differences between fabrics, treatments and the fabrics times the treatments.

The data from tests of surface appearance were analyzed for any significant differences between fabrics, treatments, judges, fabrics times judges, fabrics times treatments, treatments times judges and fabrics times treatments times judges.

The F distribution was used to test each source of variation. The sum of squares was caculated for each source of variation and divided by the appropriate degrees of freedom to produce the mean square. To obtain the F values, each mean square was divided by the appropriate experimental error. The five per cent and one per cent level of significance were arbitrarily chosen for rejection of the hypotheses.

The data were processed on the Remington Rand Univac 1105 at The Computation Center at The University of North Carolina. The programs used to process these data are found in Appendix A.

CHAPTER IV

PRESENTATION OF DATA

I. FABRIC CONSTRUCTION

Before experimentation all three fabrics were tested to determine the fiber length, yarn number, twist count, thread count, and weight. These tests were made to be certain that the basic construction was the same for all three fabrics. The mean results of these tests on the three fabrics are shown in Table II. The slight differences between the laboratory tests and the data supplied by the manufacturer were considered due to differences between specifications and the manufactured fabrics.

TABLE II

MEAN RESULTS OF FABRIC CONSTRUCTION TESTS

Fabric	Fiber length (Inches)		Yarn number		Twist (Inches)				Weight (Oz/ sq/yd)
	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling	
A	0.9	1.0	43's	32's	29Z	22S	82	74	3.2
B	0.9	1.0	41's	32's	27Z	21S	83	74	3.3
C	0.8	1.1	44's	31's	26Z	20S	83	75	3.1
Specifications given by the manufacturer									
	---	---	40's	30's	---	---	85	74	3.1

The principle differences which did exist in the fabrics were in the finish applied by the manufacturer. Fabric A was treated with a triazone finish, Fabric B with dimethylol ethylene urea (DMEU), Fabric C had only usual mill treatments in preparation for finishing. No resin finishing treatment was applied to Fabric C. Fabrics A and B were Sanforized.

II. PERFORMANCE OF FABRICS BEFORE EXPERIMENTATION

The Fabrics A, B, and C were tested to determine tear resistance, wrinkle recovery, and stiffness before any laundering treatment was applied. Mean results of the tests are given in Table III.

TABLE III

MEAN RESULTS OF PERFORMANCE

Fabric	Tear resistance (Pounds)		Wrinkle recovery (Degrees)	Stiffness (Inches overhang)	
	Warp	Filling		Warp	Filling
A	1.87	1.92	257	1.51	1.41
B	1.70	1.36	264	1.73	1.49
C	1.19	1.40	118	1.93	1.83
Mean	1.58	1.56	213	1.72	1.58

The fabric with no resinous finish, Fabric C, was lower in warp tear resistance and wrinkle recovery than either Fabrics A or B. The filling tear resistance of Fabric B was slightly less than the filling tear resistance of Fabric C. The stiffness of Fabric C was higher than either of the resin finished fabrics. This would indicate that the fabrics with resinous finishes were softer and superior in tear resistance and wrinkle recovery.

III. PERFORMANCE OF FABRICS AFTER LAUNDERING

In this section of the study, comparisons of the effectiveness of the four fabric softeners were based upon the means of tests applied to each of the three fabric types. Comparisons made between fabrics to which no softener had been applied and those treated with a softener were based upon the mean of means of the three fabrics. This applied to tests made both before laundering and those made at each testing interval.

Dimensional Change

There were differences in the shrinkage of the three fabrics. Warp dimensional change of Fabrics A and B were slight and well below the 1.0 per cent established for Sanforized fabrics. Fabric C had the greatest shrinkage of all the fabrics. The shrinkage ranged from 2.50 per cent at the first interval to 4.16 per cent at the twenty-fourth interval. In the filling direction the fabric with the least shrinkage at all intervals was Fabric B. Fabric C was also the highest in shrinkage in the filling direction (Table IV, Figure 1). These changes were expected since Fabric C was not Sanforized. These differences in the fabrics were found to be statistically significant at the one per cent level at all the intervals (Appendix B).

TABLE IV

DIFFERENCES IN FABRICS AS INDICATED
BY DIMENSIONAL CHANGE

Interval	Per cent Warp Change Fabric			Per cent Filling Change Fabric		
	A	B	C	A	B	C
1	-0.18	-0.01	-2.50	-0.76	-0.47	-7.67
3	0.22	0.09	-2.89	-0.88	-0.59	-8.29
6	0.10	-0.04	-3.30	-1.09	-0.65	-8.43
12	0.00	-0.20	-4.03	-1.22	-0.72	-8.17
24	0.29	0.00	-4.16	-1.02	-0.49	-7.25

The effect of the fabric softeners on the dimensional change varied little between softeners. In the warp direction there was less

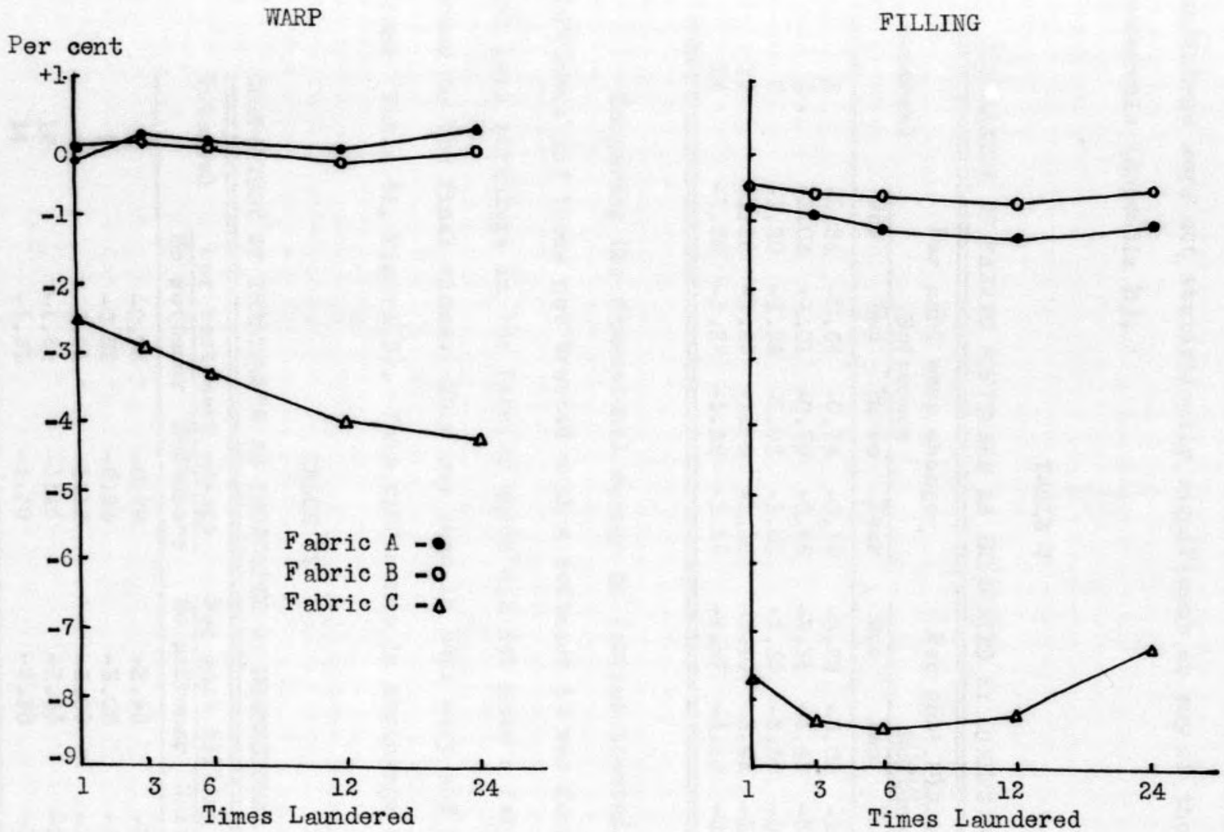

FIGURE 1

DIFFERENCES IN FABRICS AS INDICATED BY DIMENSIONAL CHANGE shrinkage than in the filling direction. There was continuous shrinkage up to the sixth interval but the fabrics began to show less shrinkage at the twenty-fourth interval (Table V, Figure 2). The differences in the shrinkage were not statistically significant at any of the laundering intervals (Appendix B).

TABLE V

COMPARISON OF FABRIC SOFTENERS AS INDICATED BY DIMENSIONAL CHANGE

Interval	Per cent warp change Softeners				Per cent filling change Softeners			
	One	Two	Three	Four	One	Two	Three	Four
1	-0.84	-0.64	-0.74	-0.89	-3.29	-3.02	-2.42	-3.16
3	-1.03	-1.01	-0.89	-0.86	-3.34	-3.42	-3.12	-3.30
6	-1.20	-1.24	-1.03	-1.01	-3.39	-3.59	-3.38	-3.49
12	-1.59	-1.23	-1.64	-1.38	-3.40	-3.42	-3.26	-3.47
24	-1.39	-1.27	-1.39	-1.16	-2.87	-3.10	-2.87	-3.21

Comparing the dimensional change of fabrics treated with the four softeners and those not treated with a softener it was found that there was less shrinkage in the fabrics which did not have a fabric softener added to the final rinse. This was true in both warp and filling directions (Table VI, Figure 3). This difference in shrinkage was significant

TABLE VI

COMPARISON OF TREATMENTS AS INDICATED BY DIMENSIONAL CHANGE

Interval	Per cent warp change		Per cent filling change	
	No softener	Softeners	No softener	Softeners
1	-0.76	-0.78	-2.93	-2.97
3	-0.52	-0.95	-3.08	-3.30
6	-0.91	-1.12	-3.09	-3.46
12	-1.21	-1.46	-3.33	-3.39
24	-1.21	-1.30	-2.53	-3.01

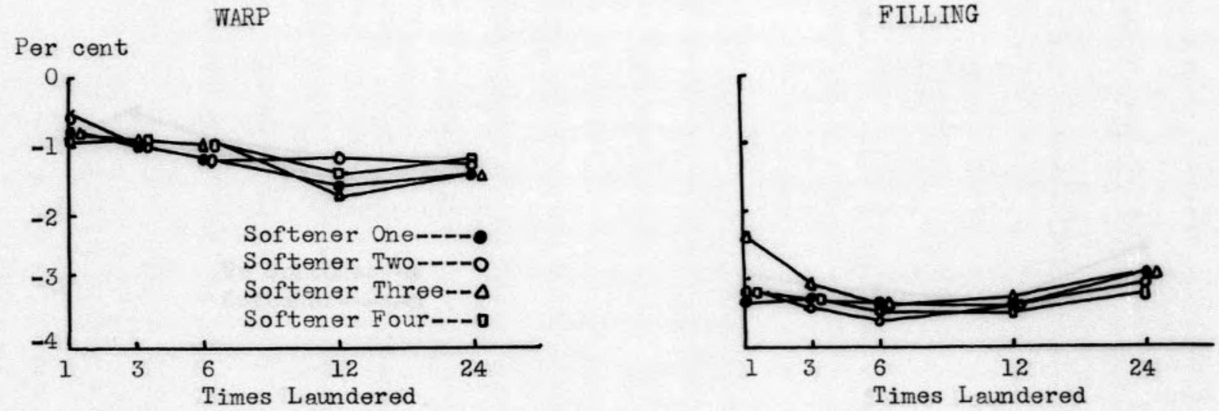

FIGURE 2

COMPARISON OF FABRIC SOFTENERS AS INDICATED BY DIMENSIONAL CHANGE

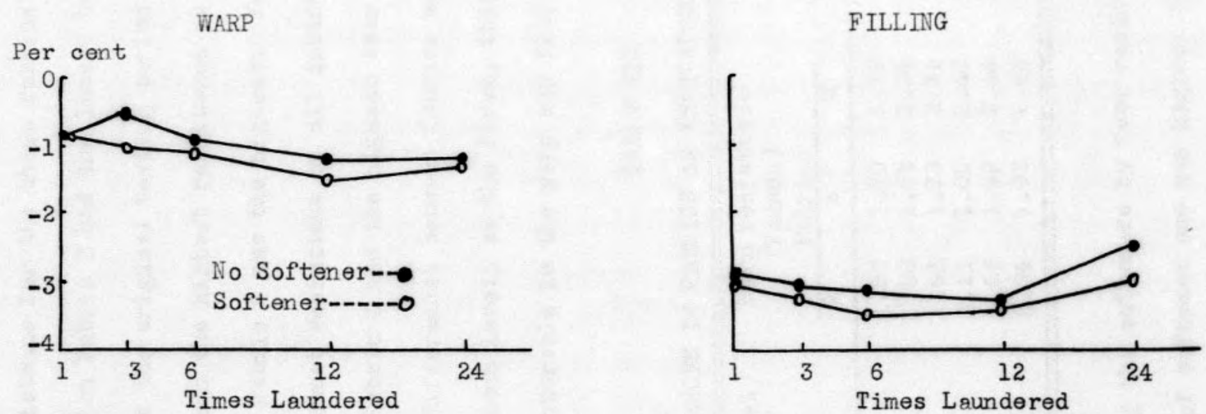

FIGURE 3

COMPARISON OF TREATMENTS AS INDICATED BY DIMENSIONAL CHANGE at the third, sixth, and twelfth intervals in the warp direction (Appendix B).

Tear Resistance

Tear resistance for the three fabrics was reported in pounds. In the warp direction Fabric B had the lowest tear resistance at all testing intervals except the original testing period when Fabric C was the lowest. Fabric A had the highest resistance at this interval, but in all other intervals Fabric C was the highest. In the filling direction Fabric B had the lowest resistance at all intervals. At all except the first interval Fabric C had the highest tear resistance (Table VII, Figure 4). These differences between fabrics were statistically significant at the one per cent level, at the first, third, sixth, twelfth, and twenty-fourth intervals in the warp and filling directions (Appendix C).

TABLE VII

DIFFERENCES IN FABRICS AS INDICATED BY TEAR RESISTANCE

Interval	Warp resistance (Pounds) Fabrics			Filling resistance (Pounds) Fabrics		
	A	B	C	A	B	C
0	1.87	1.70	1.19	1.92	1.36	1.40
1	1.90	1.73	2.04	1.98	1.36	2.36
3	1.91	1.79	2.25	1.96	1.48	2.60
6	2.11	1.92	2.49	2.11	1.62	2.49
12	1.95	1.88	2.44	2.00	1.58	2.77
24	2.04	1.93	2.40	2.13	1.72	2.78

Comparing the softeners by tear resistance of the fabrics, the warp direction of softener one was highest at all intervals except the twelfth. Softener four was lowest in tear resistance at all intervals. In the filling direction no one softener remained highest at any of the

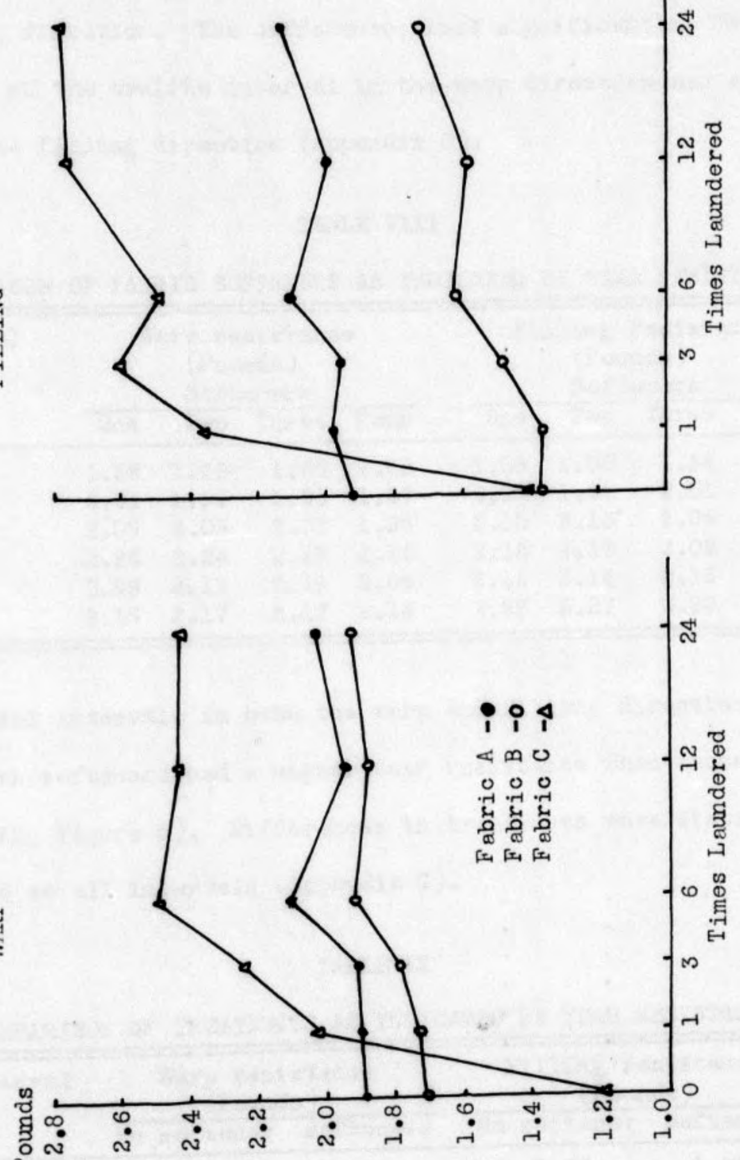

FIGURE 4

DIFFERENCES IN FABRICS AS INDICATED BY TEAR RESISTANCE six intervals (Table VIII, Figure 5). Differences in these softeners were statistically significant at the one per cent level at the first and third intervals in the warp direction and at the first interval in the filling direction. The differences were significant at the five per cent level at the twelfth interval in the warp direction and at the third in the filling direction (Appendix C).

TABLE VIII

COMPARISON OF FABRIC SOFTENERS AS INDICATED BY TEAR RESISTANCE

Interval	Warp resistance (Pounds) Softeners				Filling resistance (Pounds) Softeners			
	One	Two	Three	Four	One	Two	Three	Four
0	1.58	1.58	1.58	1.58	1.56	1.56	1.56	1.56
1	2.01	1.99	1.93	1.87	2.07	1.95	2.01	1.85
3	2.09	2.05	2.02	1.98	2.10	2.13	2.04	2.04
6	2.26	2.24	2.18	2.16	2.12	2.19	2.09	2.01
12	2.09	2.11	2.14	2.09	2.15	2.14	2.16	2.10
24	2.18	2.17	2.17	2.13	2.26	2.27	2.20	2.21

At all intervals in both the warp and filling directions fabrics treated with softeners had a higher tear resistance than those not treated (Table IX, Figure 6). Differences in treatments were statistically significant at all intervals (Appendix C).

TABLE IX

COMPARISON OF TREATMENTS AS INDICATED BY TEAR RESISTANCE

Interval	Warp resistance (Pounds)		Filling resistance (Pounds)	
	No softener	Softeners	No softener	Softeners
0	1.58	1.58	1.56	1.56
1	1.64	1.95	1.61	1.97
3	1.78	2.28	1.79	2.08
6	2.04	2.21	1.96	2.10
12	2.03	2.11	2.04	2.14
24	2.02	2.18	2.13	2.23

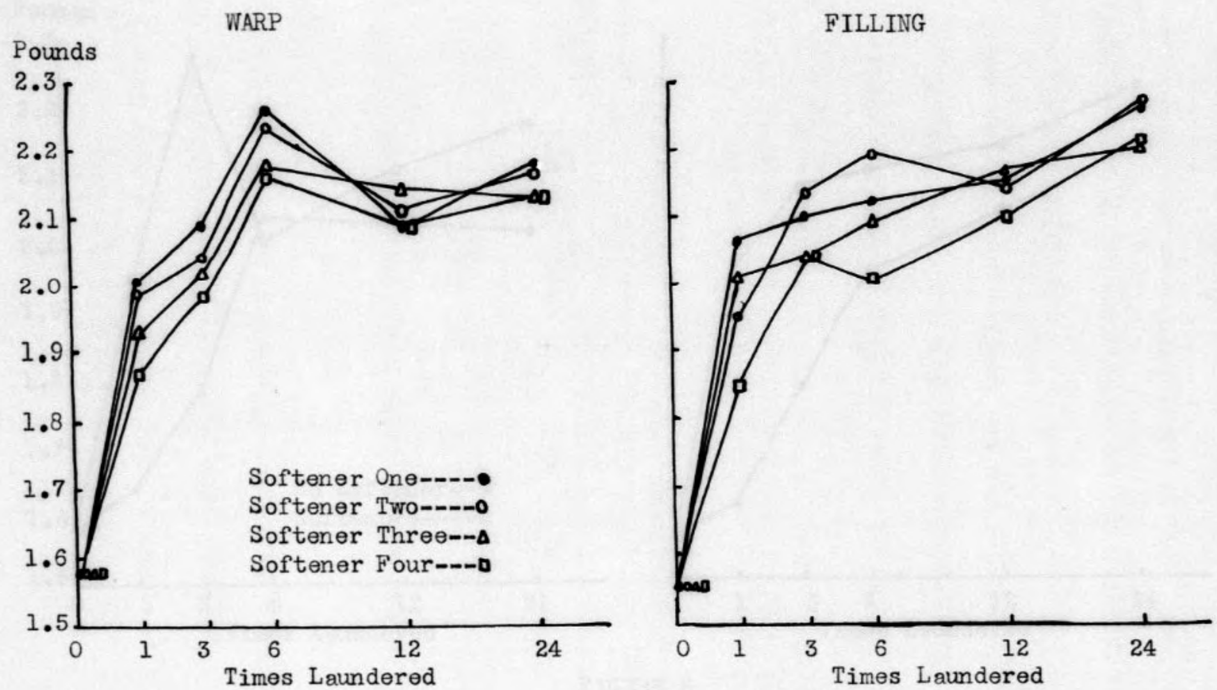

FIGURE 5

COMPARISON OF FABRIC SOFTENERS AS INDICATED BY TEAR RESISTANCE

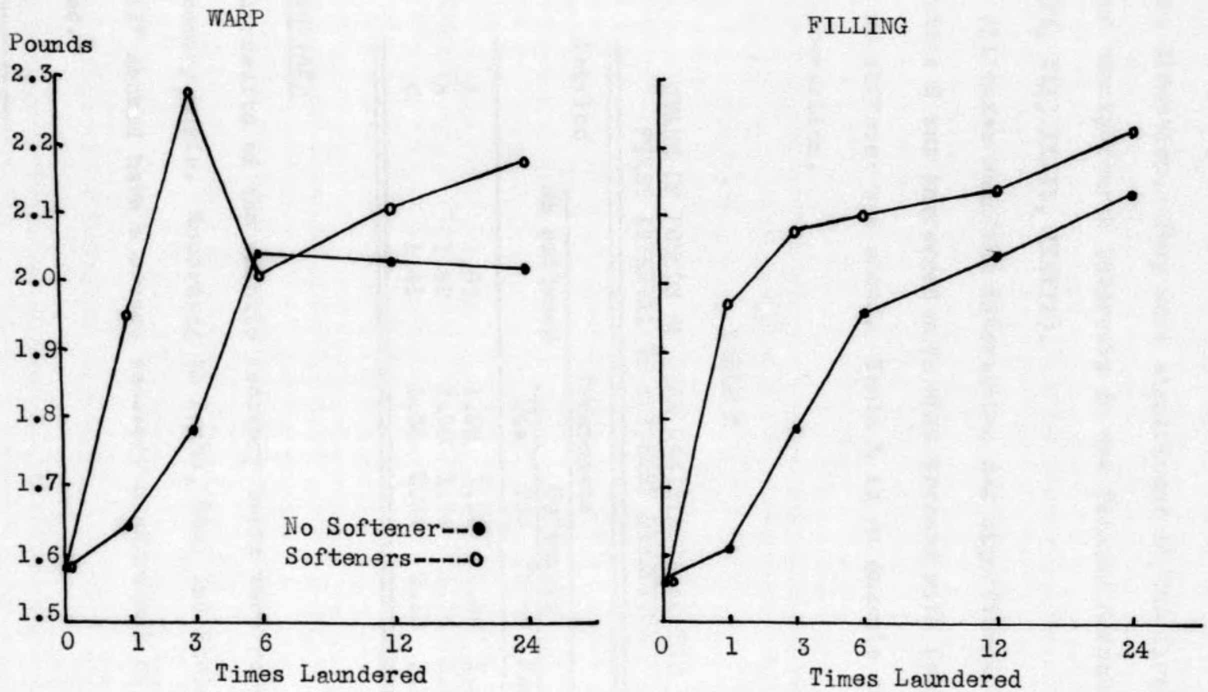

FIGURE 6

COMPARISON OF TREATMENTS AS INDICATED BY TEAR RESISTANCE

The interactions between the fabrics and treatments were found to be statistically significant at the first, third and twelfth intervals in the warp direction. They were significant at the first, third, twelfth and twenty-fourth intervals in the filling direction (Appendix C, Tables XXIX, XXX, XXXII, XXXIII).

In all cases when the interaction was significant the tear resistance of Fabric C was increased more when treated with fabric softeners than when no softener was added. Table X is an example showing a significant interaction.

TABLE X

MEANS OF POUNDS OF TEAR RESISTANCE AT THE FIRST INTERVAL IN THE WARP DIRECTION

Fabrics	Treatments				
	No softener	Softeners			
		One	Two	Three	Four
A	1.83	1.92	1.91	1.88	1.97
B	1.68	1.80	1.74	1.74	1.68
C	1.41	2.30	2.34	2.18	1.96

Wrinkle Recovery

The results of the wrinkle recovery tests were recorded in degrees of the recovery angle. According to Taube, Ross and Poole "wash and wear fabric" should have a crease recovery measurement of 275 degrees to 230 degrees.[1]

[1]R. Katherine Taube, Enid S. Ross and Nada D. Poole, "Use of Modern Home Laundry Equipment I. Wrinkling Effects on Swatches of Present-Day Fabrics," American Dyestuff Reporter, (June 26, 1961), p. 38.

There were differences in the angle of recovery for the three fabrics. At each interval of testing; Fabric A had the highest recovery, and Fabric C had the lowest. The wash and wear finish applied by the manufacturer to Fabrics A and B was evident in the results of this test at each laundering interval (Table XI, Figure 7). The differences in the three fabrics were statistically significant at the one per cent level at all the testing intervals (Appendix D).

TABLE XI

DIFFERENCES IN FABRICS AS INDICATED BY WRINKLE RECOVERY

Interval	Fabrics (Degrees)		
	A	B	C
0	257	264	118
1	259	256	148
3	258	256	164
6	261	255	172
12	264	258	174
24	265	259	177

In all cases the wrinkle recovery of the fabrics increased from the original after laundering with the four fabric softeners. There was a range of a low of 218 degrees after the first washing interval to a high of 237 degrees after twenty-four washings. Softener number three was the lowest of the four softeners through the sixth washing but was the highest after the twenty-fourth laundering (Table XII, Figure 8). There were slight differences between softeners at each interval; however, these were not great enough to show one softener superior to another. These differences were statistically significant at the twenty-fourth interval at the one per cent level (Appendix D).

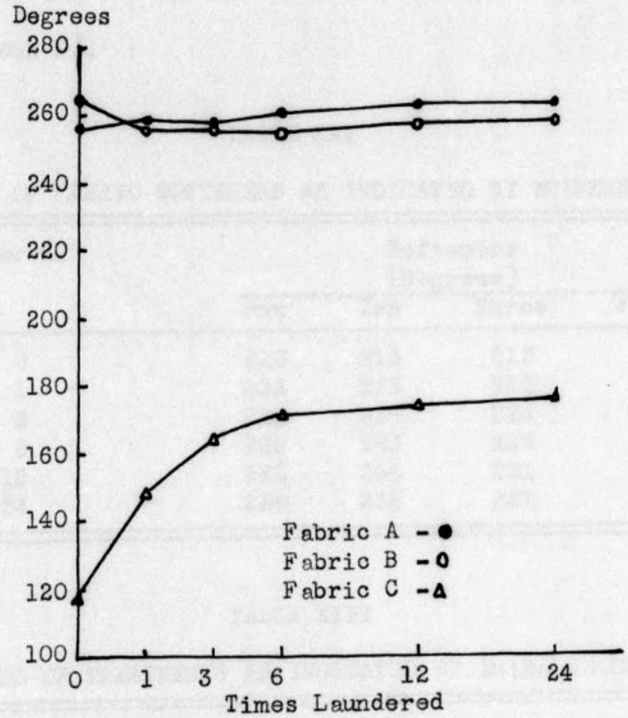

FIGURE 7

DIFFERENCES IN FABRICS AS INDICATED BY WRINKLE RECOVERY

After each testing interval fabrics treated with a softener had a higher angle of recovery than did fabrics not treated with a fabric softener (Table XIII, Figure 9). These differences were not large, but were statistically significant at the five per cent level at the third and twelfth intervals and the one per cent level at the twenty-fourth interval (Appendix D).

TABLE XII

COMPARISON OF FABRIC SOFTENERS AS INDICATED BY WRINKLE RECOVERY

Interval	Softeners (Degrees)			
	One	Two	Three	Four
0	213	213	213	213
1	223	223	218	220
3	228	228	224	228
6	229	233	226	232
12	231	234	234	232
24	234	235	237	235

TABLE XIII

COMPARISON OF TREATMENTS AS INDICATED BY WRINKLE RECOVERY

Interval	No softener (Degrees)	Softeners (Degrees)
0	213	213
1	220	221
3	221	227
6	227	230
12	227	233
24	227	235

The interaction between the fabrics and the treatments were found to be statistically significant at the third, sixth and twenty-fourth intervals at the one per cent level (Appendix D, Tables XXXVI, XXXVII, XXXIX).

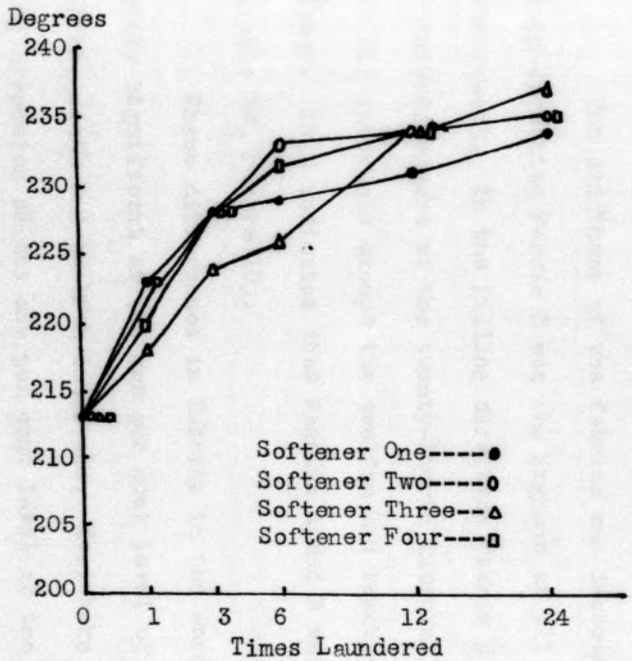

FIGURE 8

COMPARISON OF FABRIC SOFTENERS AS INDICATED BY WRINKLE RECOVERY

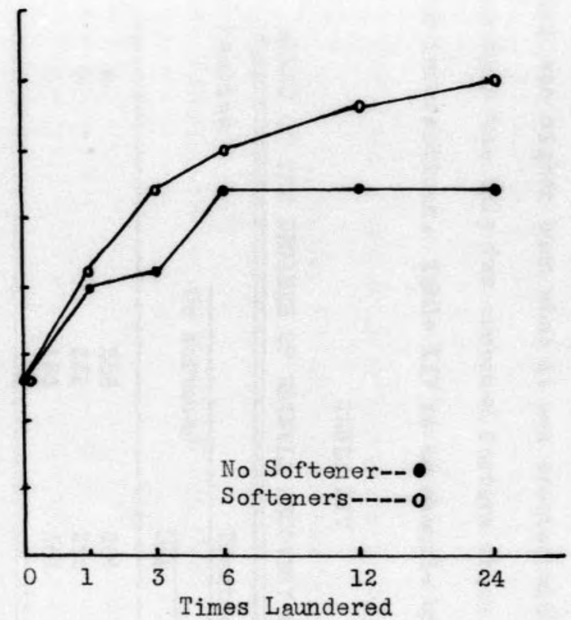

FIGURE 9

COMPARISON OF TREATMENTS AS INDICATED BY WRINKLE RECOVERY

When Fabric B was treated with softener two the wrinkle recovery rating was higher than when it was treated with the other softeners. These were the only two combined factors which were repeated in all three interactions. Table XIV is an example of this interaction.

TABLE XIV

MEANS OF THE DEGREES OF WRINKLE RECOVERY AT THE THIRD INTERVAL

Fabrics	Treatments				
	No softener	Softeners			
		One	Two	Three	Four
A	256	264	261	254	257
B	251	256	260	254	257
C	154	164	164	164	172

Stiffness

The stiffness of the fabrics was decreased with washings. In the warp direction Fabric C was the highest at all intervals, Fabric B was the lowest. In the filling direction Fabric C was the highest at all intervals except at the twenty-fourth interval. Fabric A was the lowest at all intervals except the twelfth and twenty-fourth when Fabric B was lower. This indicates that Fabrics A and B were softer than Fabric C (Table XV, Figure 10).

These differences in fabrics in the warp direction were statistically significant at the one per cent level of probability at the first, third, sixth and twelfth intervals. They were significant in the filling direction at the one per cent level at the third and twelfth intervals and at the five per cent level at the first and twenty-fourth intervals (Appendix E).

In the warp direction fabrics treated with the four softeners at the first interval varied from a low of 1.43 to a high of 1.52. At the other intervals the difference was no greater than .04 inches. In the filling direction the greatest difference occurred at the first interval where there was a variation of .08 inches. After the twenty-fourth washing only .01 inches variation occurred (Table XVI, Figure 11). These differences in warp stiffness were statistically significant at the five per cent level, at the third, sixth and twenty-fourth intervals. (Appendix E).

TABLE XV

DIFFERENCES IN FABRICS AS INDICATED BY STIFFNESS

Interval	Warp stiffness (Inches overhang)			Filling stiffness (Inches overhang)		
	A	B	C	A	B	C
0	1.51	1.73	1.93	1.41	1.49	1.83
1	1.36	1.49	1.56	1.33	1.35	1.42
3	1.29	1.39	1.47	1.29	1.32	1.42
6	1.29	1.39	1.47	1.33	1.35	1.35
12	1.30	1.32	1.36	1.34	1.32	1.36
24	1.30	1.30	1.32	1.33	1.30	1.32

TABLE XVI

COMPARISON OF FABRIC SOFTENERS AS INDICATED BY STIFFNESS

Interval	Warp stiffness (Inches overhang) Softeners				Filling stiffness (Inches overhang) Softeners			
	One	Two	Three	Four	One	Two	Three	Four
0	1.72	1.72	1.72	1.72	1.58	1.58	1.58	1.58
1	1.43	1.44	1.50	1.52	1.34	1.34	1.36	1.40
3	1.36	1.32	1.38	1.37	1.33	1.35	1.36	1.32
6	1.34	1.32	1.36	1.35	1.35	1.32	1.35	1.34
12	1.32	1.32	1.32	1.32	1.34	1.34	1.33	1.33
24	1.31	1.29	1.30	1.29	1.31	1.31	1.31	1.30

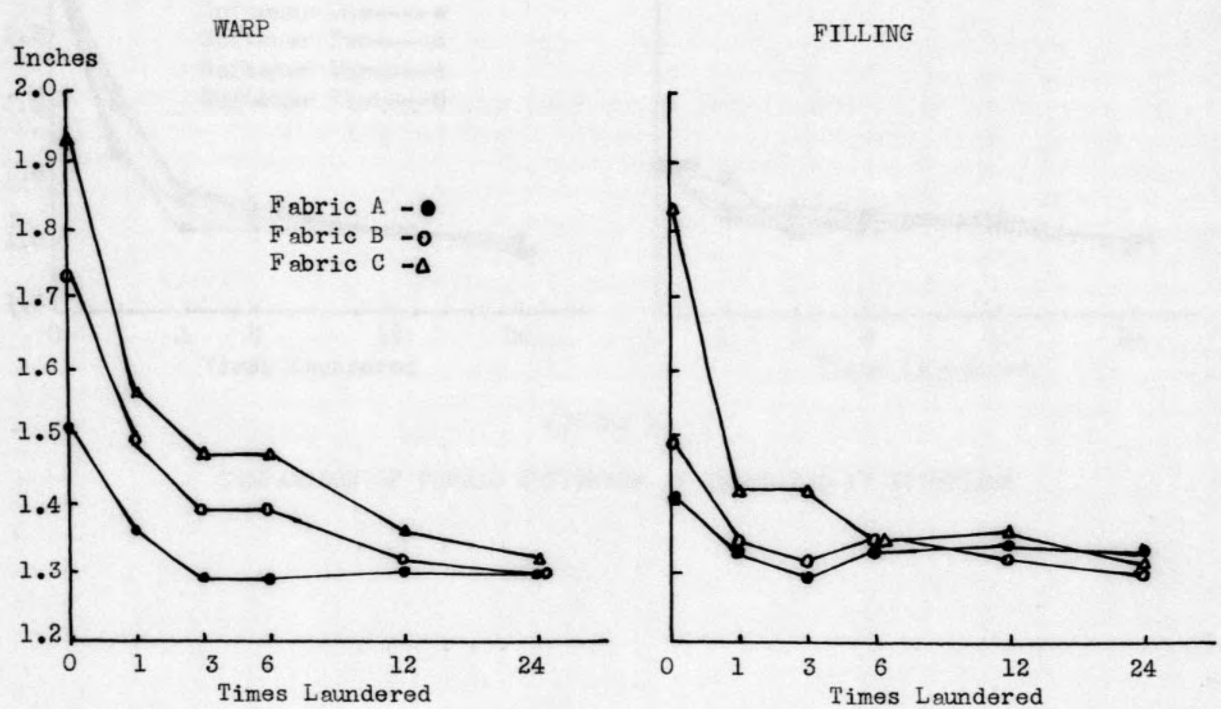

FIGURE 10

DIFFERENCES IN FABRICS AS INDICATED BY STIFFNESS

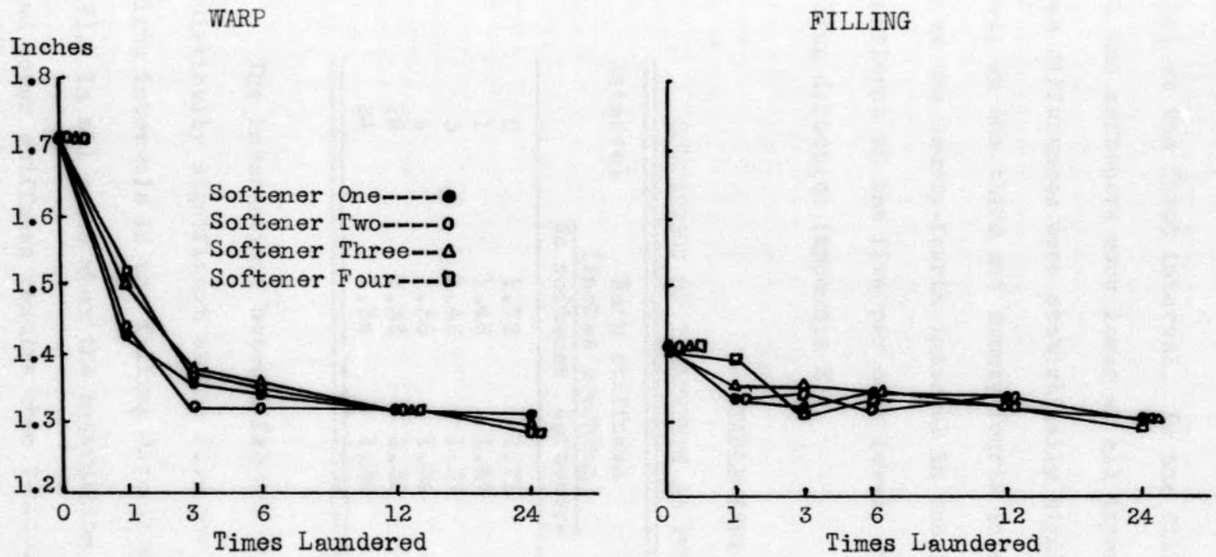

FIGURE 11

COMPARISON OF FABRIC SOFTENERS AS INDICATED BY STIFFNESS

In the warp direction fabrics treated with a fabric softener were lower in stiffness than those not treated with a softener in all cases except at the first interval. In the filling direction fabrics treated with the softeners were lower at all intervals (Table XVII, Figure 12). These differences were statistically significant at the one per cent level, at the third and twenty-fourth intervals in the warp direction and at the twenty-fourth interval in the filling direction. They were significant at the five per cent level, at the twelfth interval in the filling direction (Appendix E).

TABLE XVII

COMPARISON OF TREATMENTS AS INDICATED BY STIFFNESS

Interval	Warp stiffness (Inches overhang)		Filling stiffness (Inches overhang)	
	No softener	Softeners	No softener	Softeners
0	1.72	1.72	1.58	1.58
1	1.46	1.47	1.39	1.36
3	1.43	1.37	1.36	1.34
6	1.36	1.34	1.35	1.34
12	1.33	1.32	1.35	1.33
24	1.34	1.30	1.34	1.31

The interactions between fabrics and treatments were found to be statistically significant at the five per cent level at the third and twelfth intervals in the filling directions (Appendix E, Tables XLII, XLIV). In all cases when the interaction was significant Fabrics A and B had lower stiffness results when fabrics were treated with the fabric softeners than when no softener was added. Table XVIII is an example of this interaction.

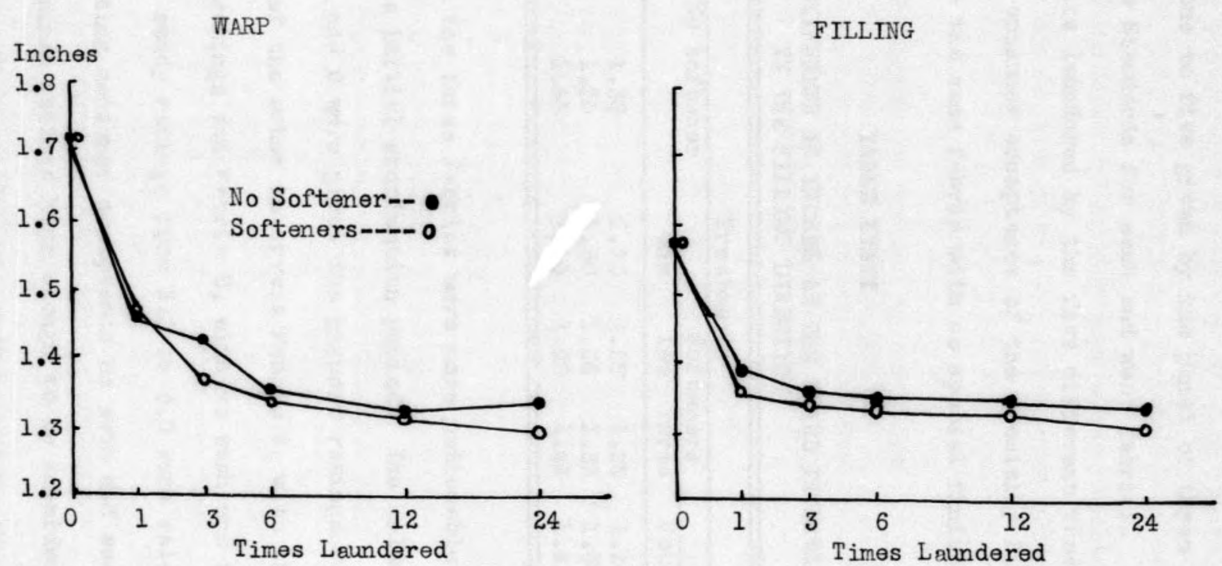

FIGURE 12

COMPARISON OF TREATMENTS AS INDICATED BY STIFFNESS

IV. EVALUATION OF THE SURFACE APPEARANCE

Ratings from one to five given by the panel of three judges were based on the Monsanto Standards for wash and wear fabrics. The ratings given the three fabrics laundered by the five different treatments were used to indicate the consumer acceptance of the specially finished fabrics as compared with the same fabric with no special finish.

TABLE XVIII

MEANS OF STIFFNESS IN INCHES AT THE THIRD INTERVAL IN THE FILLING DIRECTION

Fabric	Treatments				
	No softener	Softeners			
		One	Two	Three	Four
A	1.30	1.30	1.28	1.29	1.26
B	1.30	1.30	1.36	1.35	1.30
C	1.48	1.40	1.40	1.43	1.41

Differences in the three fabrics were more noticeable following laundering than at the initial examination period. The unlaundered samples of Fabrics A, B, and C were given the highest ratings ranging from 4.8 to 5.0. At each of the other intervals Fabric B, with the DMEU finish, had the highest ratings and Fabric C, with no wash and wear finish, the lowest. For this study ratings from 3.0 to 5.0 were selected to indicate fabrics meriting consumer acceptance as wash and wear fabrics. Fabrics A and B maintained ratings high enough to be considered wash and wear fabrics (Table XIX, Figure 13). The differences in the fabrics were found to be statistically significant at the one per cent level at all laundering intervals (Appendix F).

The evaluations of fabrics treated with each of the four fabric softeners ranged from a high of 4.9 to a low of 2.9. There was a large decrease in ratings at the first laundering interval. At all subsequent intervals this rating remained relatively consistent (Table XX, Figure 14). There were statistically significant differences among treatments

TABLE XIX

DIFFERENCES IN FABRICS AS INDICATED BY SURFACE APPEARANCE RATINGS

Interval	Fabrics		
	A	B	C
0	4.8	5.0	4.9
1	3.1	3.9	1.3
3	3.4	4.1	1.3
6	3.4	4.1	1.2
12	3.4	4.1	1.5
24	3.4	4.1	1.5

TABLE XX

COMPARISON OF FABRIC SOFTENERS AS INDICATED BY SURFACE APPEARANCE RATINGS

Interval	Softeners			
	One	Two	Three	Four
0	4.9	4.9	4.9	4.9
1	2.8	2.9	2.8	2.9
3	2.9	2.9	2.8	2.9
6	2.9	2.9	2.7	2.8
12	3.0	3.0	3.2	3.2
24	3.0	3.1	2.9	3.0

at the five per cent level at the first and twenty-fourth intervals and at the one per cent level at the sixth and twelfth intervals (Appendix F). Although the differences among softeners were statistically significant, the ratings did not vary enough to indicate the fabric softeners

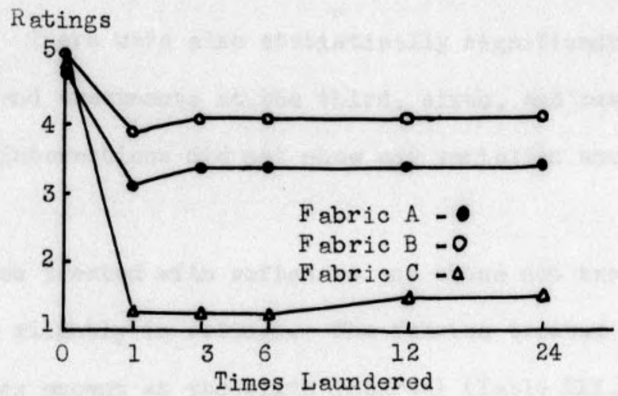

FIGURE 13

DIFFERENCES IN FABRICS AS INDICATED
BY SURFACE APPEARANCE RATINGS

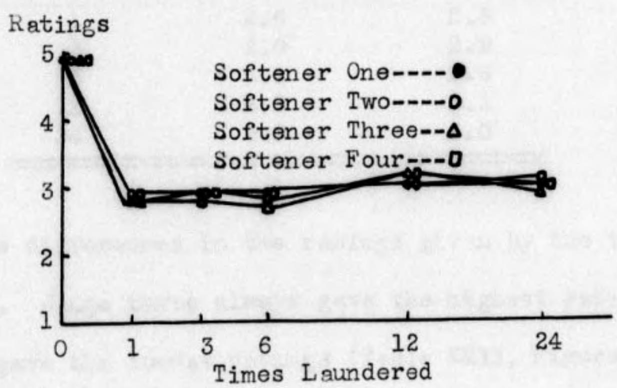

FIGURE 14

COMPARISON OF FABRIC SOFTENERS AS INDICATED
BY SURFACE APPEARANCE RATINGS

to be effective. There were also statistically significant interactions between fabrics and treatments at the third, sixth, and twelfth intervals, but these interactions did not show any variation among the four softeners.

The fabrics treated with softeners and those not treated with softeners varied slightly in ratings. The fabrics treated with softeners had higher ratings except at the sixth interval (Table XXI, Figure 15). The differences in the treatments were not statistically significant at any of the laundering intervals.

TABLE XXI

COMPARISON OF TREATMENTS AS INDICATED BY SURFACE APPEARANCE RATINGS

Interval	No softener	Softeners
0	5.0	4.9
1	2.6	2.8
3	2.9	2.9
6	3.1	2.6
12	3.0	3.1
24	3.0	3.0

There were differences in the ratings given by the three judges at all intervals. Judge three always gave the highest ratings. In most cases Judge one gave the lowest ratings (Table XXII, Figure 16). These differences between judges were statistically significant at all the intervals at the one per cent level (Appendix F).

TABLE XXII

DIFFERENCES IN SURFACE APPEARANCE RATINGS GIVEN BY THE THREE JUDGES

Interval	Judges		
	One	Two	Three
0	4.8	5.0	5.0
1	2.5	2.5	3.3
3	2.6	2.7	3.5
6	2.6	2.7	3.3
12	2.6	2.7	3.8
24	2.6	2.7	3.8

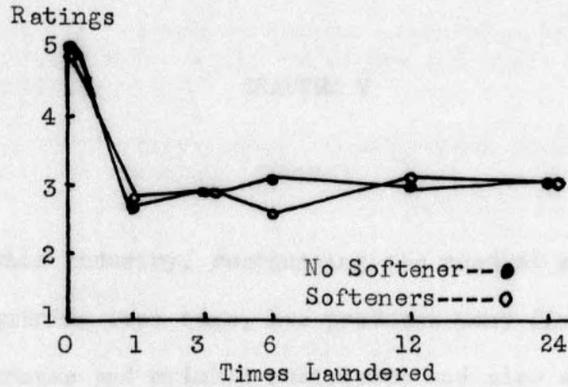

FIGURE 15

COMPARISON OF TREATMENTS AS INDICATED
BY SURFACE APPEARANCE RATINGS

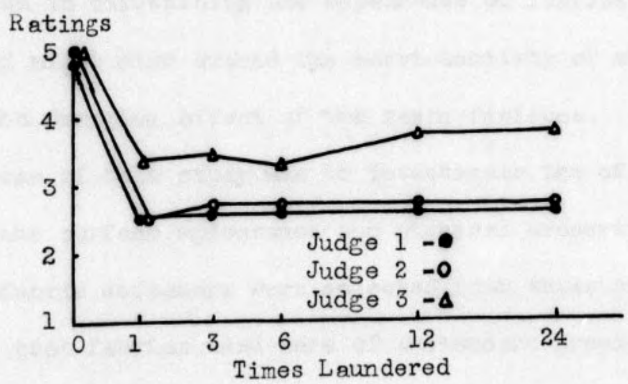

FIGURE 16

DIFFERENCES IN SURFACE APPEARANCE RATINGS
GIVEN BY THE THREE JUDGES

CHAPTER V

SUMMARY

The textile industry, recognizing the need of modern consumers for fabrics requiring less care, has produced many finishes to impart properties of crease and wrinkle resistance and also wash and wear characteristics to cotton fabrics. Fabric softeners were first applied to these resin treated fabrics to maintain the pliability, softness and strength of the fabrics.

In recent years fabric softeners have gained popularity as home laundering aids. Their value in maintaining softness in towels, rugs and other textile products has been recognized. It is thought that they might be of value in maintaining the appearance of fabrics treated for ease of care and might also extend the serviceability of such fabrics by counteracting the damaging effect of the resin finishes.

The purpose of this study was to investigate the effectiveness of softeners upon the surface appearance and physical properties of fabrics. Four brands of fabric softeners were selected from those commercially available. The test fabrics used were of a standard broadcloth construction varying in finishing treatments, namely: Fabric A was treated with a triazone finish; Fabric B was treated with dimethylol ethylene urea (DMEU); and Fabric C had only usual mill treatments in preparation for finishing. The fabrics were laundered twenty-four times and tested at designated intervals to determine:

(1) The differences in surface appearance between the fabrics treated with fabric softeners and those not treated with a softener.

(2) The differences among the softeners in maintaining the surface appearance.

(3) The differences in physical properties between the fabrics treated with a fabric softener and those not treated with a softener.

(4) The differences among the softeners as indicated by the physical properties of the fabrics.

Laboratory tests and measurements used to indicate the differences in the three test fabrics were dimensional change, tear resistance, wrinkle recovery, stiffness and surface appearance. The data were tested for their significance at the five and one per cent levels by using an Analysis of Variance.

The differences in the finish of the fabrics contributed to differences in physical tests. These were apparent in the fabric both before laundering and after laundering. In many cases the differences were due to the Fabric C which had no finish other than the regular mill finish. The differences among the fabrics were statistically significant for all physical tests performed.

Fabrics A and B had less shrinkage at all laundering intervals than the maximum for Sanforized fabrics in both the warp and filling directions. Fabric C had more shrinkage than the maximum for Sanforizing. There was less shrinkage of the fabrics laundered without a fabric softener added to the rinse water than those treated with a softener. However, this difference was not great enough to be statistically significant.

All three fabrics increased in tear resistance after laundering. Fabric C increased more than did Fabrics A and B. The fabrics treated with a fabric softener increased in tear resistance slightly more than the fabrics not treated with a softener. This difference was not considered to be of importance except in Fabric C where it was found that the addition of a fabric softener did increase the tear resistance.

Throughout all the laundering intervals Fabrics A and B maintained the degrees of wrinkle recovery which would enable them to be considered wash and wear fabrics. At none of the intervals did Fabric C have an angle of recovery equivalent to a wash and wear fabric. The wrinkle recovery angle of Fabric C did increase after laundering but this was as prevalent in the samples laundered without the softener as in those treated with a softener.

The stiffness of all three fabrics was decreased after the launderings but this was not found to be due to the addition of the fabric softeners.

In only one of all the physical tests performed was it found that a fabric softener was of any benefit. This was in the tear resistance of Fabric C which was increased by the use of a fabric softener. In no cases was it found that one fabric softener was superior to another.

From the evaluations of the surface appearance it was shown that Fabrics A and B maintained ratings sufficient for wash and wear fabrics. Fabric C did not maintain a rating above 1.5 after the initial judging. There were no differences found among the four softeners; however, there were some differences found between fabrics not treated with a softener. These differences were so slight that they would not make any difference to consumer use.

The conclusions reached from this study were that fabric softeners did not help to maintain the surface appearance and physical properties of fabrics treated to have wash and wear properties. There were no differences in the effectiveness of the fabric softeners selected.

Since fabric softeners have increased in production and sales in recent years it is suggested that further study be made of the application of fabric softeners to determine their true value. It is suggested that fabric softeners be applied to knit or pile fabrics rather than flat surface fabrics such as used in this study.

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APPENDIX

APPENDIX A

COMPUTER PROGRAMS FOR THE STATISTICAL ANALYSIS OF DATA

I. Computer program for the statistical analysis of data for dimensional change, tear resistance, wrinkle recovery and stiffness.

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      N 0010   Y 0040   Z 0070   S 0070   W 000                 TH
0062  NEELY R276  Y1----Y30   INPUT                             F
0001  TYO   T(62.)                                              F
      4,N1,1,1,15,                                              F
0070  N2:-1+2XN1                                                F
      ZN1:YN2+Y(N2+1)                                           F
0004  Z(N1+15):ZNL/2.                                           F
      5,N1,31,1,36,                                             F
0069  N2:-30+N1                                                 F
0005  ZN1:YN2+Y(N2+6)+Y(N2+12)+Y(N2+18)+Y(N2+24)                F
      6,N1,37,1,39,                                             F
0068  N2:-36+N1                                                 F
0006  ZN1:ZN2+Z(N2+3)+Z(N2+6)+Z(N2+9)+Z(N2+12)                  F
      7,N1,40,1,42,                                             F
0067  N2:-24+N1                                                 F
0007  ZN1:ZN2+Z(N2+3)+Z(N2+6)+Z(N2+9)+Z(N2+12)                  F
      8,N1,43,1,47,                                             F
0066  N2:-128+3XN1                                              F
      ZN1:ZN2+Z(N2+1)+Z(N2+2)                                   F
0008  Z(N1+6):ZN1/6.                                            F
```

APPENDIX A (Continued)

```
       Z48:Z37+Z38+Z39                                          F
       12,N1,1,1,15,                                            F
0060   TZN1   TZ(N1+15)   TZ(N1+30)   TZ(N1+42)                 F
0012   T(0)                                                     F
       Z54:Z48XZ48/30.                                          F
       Z55:(Z37XZ37)+(Z38xZ38)+(Z39xZ39)                        F
       Z55:(Z55/10.)-Z54                                        F
       Z56:(Z43XZ43)+(Z45XZ45)+
       Z56:(Z43XZ43)+(Z44XZ44)+(Z45XZ45)+(Z46XZ46)+(Z47XZ47)    F
       Z56:(Z56/6.)-Z54                                         F
       Z0:0.                                                    F
       9,N1,1,1,15,                                             F
0009   Z0:Z0+(ZN1XZN1)                                          F
       Z57:(Z0/2.)-(Z54+Z55+Z56)                                F
       Z0:0.                                                    F
       10,N1,1,1,30,                                            F
0010   Z0:Z0+(YN1XYN1)                                          F
       Z58:Z0-(Z54+Z55+Z56+Z57)                                 F
       Z59:Z55/2.                                               F
       Z60:Z56/4.                                               F
       Z61:Z57/8.                                               F
       Z62:Z58/15.                                              F
       Z63:Z59/Z62.                                             F
       Z64:Z60/Z62.                                             F
       Z65:Z61/Z62.                                             F
       11,N1,54,1,58,
```

APPENDIX A (Continued)

```
0011    TZN1  TZ(N1+5)  TZ(N1+9)                               F
        T(0.)                                                  F
        13,N1,57,1,58,                                         F
0013    ZN1:0.                                                 F
        G62                                                    FF
```

APPENDIX A (Continued)

II. Computer program for the statistical analysis of surface appearance ratings

```
        N 0010  Y 0090  Z 0215  S  0100  W 0000                  TH

0100    NEELY R276, Y1----90 INPUT                                 F
0001    TYO T(100.)                                                F
        4,N1,1,1,45,                                               F
0099    N2:-1+2XN1                                                 F
        ZN1:YN2+Y(N2+1)                                            F
0004    Z(N1+45):ZN1/2.                                            F
        5,N1,91,1,96,                                              F
0098    N2:-90+N1                                                  F
0005    ZN1:YN2+Y(N2+6)+Y(N2+12)                                   F
        30, N1,96,1,102,                                           F
0070    N2:-77+N1                                                  F
0030    ZN1:YN2+Y(N2+6)+Y(N2+12)                                   F
        31,N1,103,1,108,                                           F
0069    N2:-66+N1,                                                 F
0031    ZN1:YN2+Y(N2+6)+Y(N2+12)                                   F
        32,N1,109,1,114,                                           F
0068    N2:-54+N1                                                  F
0032    ZN1:YN2+Y(N2+6)+Y(N2+12)                                   F
        33,N1,115,1,120,                                           F
0067    N2:-42+N1                                                  F
0033    ZN1:YN2+Y(N2+6)+Y(N2+12)                                   F
        6,N1,121,1,123,                                            F
0097    N2:-120+N1                                                 F
```

APPENDIX A (Continued)

```
      ZN1:ZN2+Z(N2+3)+Z(N2+6)                F
0006  Z(N1+15):ZN1/6.                        F
      7,N1,124,1,126                         F
0096  N2:-114+N1                             F
      ZN1:ZN2+Z(N2+3)+Z(N2+6)                F
0007  Z(N1+15):ZN1/6.                        F
      8,N1,127,1,129,                        F
0095  N2:-108+N1                             F
      ZN1:ZN2+Z(N2+3)+Z(N2+6)                F
0008  Z(N1+15):ZN1/6.                        F
      9,N1,130,1,132,                        F
0094  N2:-102+N1                             F
      ZN1:ZN2+Z(N2+3)+Z(N2+6)                F
0009  Z(N1+15):ZN1/6.                        F
      10,N1,133,1,135,                       F
0093  N2:-96+N1                              F
      ZN1:ZN2+Z(N2+3)+Z(N2+6)                F
0010  Z(N1+15):ZN1/6.                        F
      11,N1,151,1,165,                       F
0066  N2:-452+3XN1                           F
      ZN1:ZN2+Z(N2+1)+Z(N2+2)                F
0011  Z(N1+20):ZN1/6.                        F
      12,N1,166,1,170,                       F
0092  N2:-347+3XN1                           F
      ZN1:ZN2+Z(N2+1)+Z(N2+2)                F
```

APPENDIX A (Continued)

```
0012    Z(N1+20):ZN1/18.                                  F
        Z191:Z166+Z167+Z168+Z169+Z170                     F
        27,N1,1,1,48,                                     F
0082    TZN1  TZ(N1+48)  TZ(N1+96)  TZ(N1+144)            F
0027    T(0.)                                             F
        Z192:Z191XZ191/90.                                F
        13,N1,121,1,123,                                  F
0091    Z0:0.                                             F
        14,N2,N1,3,N1+12,                                 F
0014    Z0:Z0+ZN2                                         F
0013    Z193:Z193+(Z0XZ0)                                 F
        Z193:(Z193/30.)-Z192                              F
        Z0:0.                                             F
        15,N1,166,1,170,                                  F
0015    Z0:Z0+(ZN1XZN1)                                   F
        Z194:(Z0/18.)-Z192                                F
        16,N1,151,1,153,                                  F
0089    Z0:0                                              F
        Z0:ZN1+Z(N1+3)+Z(N1+6)+Z(N1+9)+Z(N1+12)           F
0016    Z195:Z195+(Z0XZ0)                                 F
        Z195:(Z195/30.)-Z192                              F
        18,N1,121,1,135,                                  F
0018    Z196:Z196+(ZN1XZN1)                               F
        Z196:(Z196/6.)-(Z192+Z193+Z194)                   F
        19,N1,1,1,9,                                      F
```

APPENDIX A (Continued)

```
0087   Z0:0                                              F
       Z0:ZN1+Z(N1+9)+Z(N1+18)+Z(N1+27)+Z(N1+36)         F
0019   Z197:Z197+(Z0XZ0)                                 F
       Z197:(Z197/10.)-(Z192+Z193+Z195)                  F
       21,N1,151,1,165,                                  F
0021   Z198:Z198+(ZN1XZN1)                               F
       Z198:(Z198/6.)-(Z192+Z194+Z195)                   F
       22,N1,1,1,45,                                     F
0022   Z199:Z199+(YN1XYN1)                               F
       Z199:Z199-Z192                                    F
       N2:1                                              F
       23,N1,1,2,89,                                     F
0084   Z200:Z200+(YN1XYN1)+(Y(N1+1)XY(N1+1))             F
       Z200:Z200-(ZN2XZN2)/2.                            F
0023   N2:N2+1                                           F
       Z201:Z193/2.                                      F
       Z202:Z194/4.                                      F
       Z203:Z195/2.                                      F
       Z204:Z196/8.                                      F
       Z205:Z197/4.                                      F
       Z206:Z198/8.                                      F
       Z207:Z199/16.                                     F
       Z208:Z200/45.                                     F
       Z209:Z207/Z208                                    F
       Z210:Z206/Z208                                    F
```

APPENDIX A (Continued)

```
        Z211:Z205/Z208                                   F

        Z212:Z204/Z208                                   F

        Z213:Z203/Z208                                   F

        Z214:Z202/Z208                                   F

        Z215:Z201/Z208                                   F

        25,N1,192,1,199,                                 F

0083    TZN1  TZ(N1+8)  TZ(N1+16)                        F

0025    T(0)                                             F

        26,N1,193,1,200,                                 F

0026    ZN1:0                                            F

        G 100                                            FF
```

APPENDIX B

ANALYSIS OF VARIANCE TABLES FOR DIMENSIONAL CHANGE

TABLE XXIII

ANALYSIS OF VARIANCE FOR DIMENSIONAL CHANGE
FIRST INTERVAL

Source	Degrees of freedom	Sum of squares	Mean square	F value
WARP				
Fabrics	2	44.8092	22.4046	161.89**
Treatments	4	0.2189	0.0547	0.40
No softener vs. softeners	1	0.0030	0.0030	0.02
Remainder	3	0.2159		
Fabrics x treatments	8	1.0948	0.1368	0.99
Within cell variation	15	2.0758	0.1384	
FILLING				
Fabrics	2	331.9855	165.9927	116.54**
Treatments	4	2.6442	0.6611	0.46
No softener vs. softeners	1	0.0072	0.0072	0.01
Remainder	3	2.6370		
Fabrics x treatments	8	3.7837	0.4730	0.33
Within cell variation	15	21.3648	1.4243	

* Significant at .05.
** Significant at .01.

APPENDIX B (Continued)

TABLE XXIV

ANALYSIS OF VARIANCE FOR DIMENSIONAL CHANGE
THIRD INTERVAL

Source	Degrees of freedom		Sum of squares		Mean square	F value
WARP						
Fabrics		2		61.9439	30.9719	193.85**
Treatments		4		1.0105	0.2526	1.58
No softener vs. Softeners	1		0.8704		0.8704	5.45*
Remainder	3		0.1401			
Fabrics x treatments		8		1.1162	0.1395	0.87
Within cell variation		15		2.3965	0.1598	
FILLING						
Fabrics		2		381.4028	190.7014	832.29**
Treatments		4		0.5215	0.1304	0.57
No softener vs. softeners	1		0.1420		0.1420	0.62
Remainder	3		0.3795			
Fabrics x treatments		8		3.9091	0.4886	2.13
Within cell variation		15		3.4369	0.2291	

* Significant at .05.
** Significant at .01.

APPENDIX B (Continued)

TABLE XXV

ANALYSIS OF VARIANCE FOR DIMENSIONAL CHANGE
SIXTH INTERVAL

Source	Degrees of freedom		Sum of squares		Mean square	F value
WARP						
Fabrics		2		74.0476	37.0238	630.33**
Treatments		4		0.4618	0.1155	1.96
No softener vs. Softeners	1		0.2159		0.2159	3.68*
Remainder	3		0.2459			
Fabrics x treatments		8		0.2598	0.0325	0.55
Within cell variation		15		0.8810	0.0587	
FILLING						
Fabrics		2		382.1016	191.0508	507.92**
Treatments		4		0.8349	0.2087	0.55
No softeners vs. Softeners	1		0.6556		0.6556	1.74
Remainder	3		0.1793			
Fabrics x Treatments		8		2.0404	0.2550	0.68
Within cell variation		15		5.6421	0.3761	

* Significant at .05.
** Significant at .01.

APPENDIX B (Continued)

TABLE XXVI

ANALYSIS OF VARIANCE FOR DIMENSIONAL CHANGE
TWELFTH INTERVAL

Source	Degrees of freedom	Sum of squares	Mean square	F value
WARP				
Fabrics	2	102.8881	51.4441	818.74**
Treatments	4	0.9486	0.2371	3.77
No softener vs. Softeners	1	0.2970	0.2970	4.73*
Remainder	3	0.6516		
Fabrics x treatments	8	1.1918	0.1490	2.37
Within cell variation	15	0.9425	0.0628	
FILLING				
Fabrics	2	348.3877	174.1939	186.85**
Treatments	4	0.1641	0.0410	0.04
No softener vs. Softeners	1	0.0120	0.0120	0.01
Remainder	3	0.1521		
Fabrics x Treatments	8	2.6417	0.3302	0.35
Within cell variation	15	13.9841	0.9323	

* Significant at .05.
** Significant at .01.

APPENDIX B (Continued)

TABLE XXVII

ANALYSIS OF VARIANCE FOR DIMENSIONAL CHANGE
TWENTY-FOURTH INTERVAL

Source	Degrees of freedom		Sum of squares		Mean square	F value
WARP						
Fabrics		2		124.5871	62.2936	740.74**
Treatments		4		0.2657	0.0664	0.79
No softener vs. Softeners	1		0.0374		0.0374	0.44
Remainder	3		0.2283			
Fabrics x Treatments		8		0.4475	0.0559	0.66
Within cell variation		15		1.2614	0.0841	
FILLING						
Fabrics		2		282.8006	141.4003	128.47**
Treatments		4		1.6419	0.4105	0.37
No softener vs. Softeners	1		1.1021		1.1021	1.00
Remainder	3		0.5398			
Fabrics x Treatments		8		2.2150	0.2769	0.25
Within cell variation		15		16.5099	1.1006	

* Significant at .05.
** Significant at .01.

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APPENDIX C

ANALYSIS OF VARIANCE TABLES FOR TEAR RESISTANCE

TABLE XXVIII

ANALYSIS OF VARIANCE FOR TEAR RESISTANCE
BEFORE LAUNDERING

Source	Degrees of freedom	Sum of squares	Mean square	F value
WARP				
Fabrics	2	0.4992	0.2496	1.49
Within cell variation	3	0.5031	0.1677	
FILLING				
Fabrics	2	0.3944	0.1972	1.50
Within cell variation	3	0.3951	0.1317	

* Significant at .05.
** Significant at .01.

APPENDIX C (Continued)

TABLE XXIX

ANALYSIS OF VARIANCE FOR TEAR RESISTANCE
FIRST INTERVAL

Source	Degrees of freedom		Sum of squares		Mean square	F value
WARP						
Fabrics		2		0.4765	0.2382	19.23**
Treatments		4		0.5267	0.1317	10.63**
No softener vs. Softeners	1		0.4588		0.4588	37.00**
Remainder	3		0.0679			
Fabrics x Treatments		8		0.6651	0.0831	6.71**
Within cell variation		15		0.1858	0.0124	
FILLING						
Fabrics		2		5.0917	2.5458	144.79**
Treatments		4		0.7656	0.1914	10.89**
No softener vs. Softeners	1		0.6135		0.6135	34.86**
Remainder	3		0.1521			
Fabrics x Treatments		8		1.2398	0.1550	8.81**
Within cell variation		15		0.2637	0.0176	

* Significant at .05.
** Significant at .01.

APPENDIX C (Continued)

TABLE XXX

ANALYSIS OF VARIANCE FOR TEAR RESISTANCE
THIRD INTERVAL

Source	Degrees of freedom	Sum of squares		Mean square	F value
WARP					
Fabrics	2		1.1136	0.5568	54.96**
Treatments	4		0.3595	0.0899	8.87**
No softener vs. Softeners	1	0.3172		0.3172	31.41**
Remainder	3	0.0423			
Fabrics x Treatments	8		0.5063	0.0633	6.25**
Within cell variation	15		0.1520	0.0101	
FILLING					
Fabrics	2		6.3467	3.1734	189.34**
Treatments	4		0.4365	0.1091	6.51*
No softener vs. Softeners	1	0.3991		0.3991	23.76**
Remainder	3	0.0374			
Fabrics x Treatments	8		0.6596	0.0824	4.91**
Within cell variation	15		0.2514	0.0168	

* Significant at .05.
** Significant at .01.

APPENDIX C (Continued)

TABLE XXXI

ANALYSIS OF VARIANCE FOR TEAR RESISTANCE
SIXTH INTERVAL

Source	Degrees of freedom	Sum of squares		Mean square	F value
WARP					
Fabrics	2		1.6621	0.8311	62.75**
Treatments	4		0.1734	0.0433	3.27
No softener vs. Softeners	1	0.1387		0.1387	10.51**
Remainder	3	0.0347			
Fabrics x Treatments	8		0.2662	0.0333	2.51
Within cell variation	15		0.1986	0.0132	
FILLING					
Fabrics	2		3.8259	1.9130	103.25**
Treatments	4		0.2040	0.0510	2.75
No softener vs. Softeners	1	0.1062		0.1062	5.74*
Remainder	3	0.0978			
Fabrics x Treatments	8		0.2593	0.0324	1.75
Within cell variation	15		0.2779	0.0185	

* Significant at .05.
** Significant at .01.

APPENDIX C (Continued)

TABLE XXXII

ANALYSIS OF VARIANCE FOR TEAR RESISTANCE
TWELFTH INTERVAL

Source	Degrees of freedom	Sum of squares	Mean square	F value
WARP				
Fabrics	2	1.8832	0.9416	350.05**
Treatments	4	0.0419	0.0105	3.89*
No softener vs. Softeners	1	0.0291	0.0291	10.78**
Remainder	3	0.0128		
Fabrics x Treatments	8	0.0780	0.0097	3.62*
Within cell variation	15	0.0403	0.0027	
FILLING				
Fabrics	2	7.2609	3.6304	957.06**
Treatments	4	0.0560	0.0140	3.69
No softener vs. Softeners	1	0.0429	0.0429	11.29**
Remainder	3	0.0131		
Fabrics x Treatments	8	0.1648	0.0206	5.43**
Within cell variation	15	0.0569	0.0038	

* Significant at .05.
** Significant at .01.

APPENDIX C (Continued)

TABLE XXXIII

ANALYSIS OF VARIANCE FOR TEAR RESISTANCE
TWENTY-FOURTH INTERVAL

Source	Degrees of freedom	Sum of squares	Mean square	F value
WARP				
Fabrics	2	1.4570	0.7285	95.35**
Treatments	4	0.1084	0.0271	3.54
No softener vs. Softeners	1	0.0980	0.0980	12.89**
Remainder	3	0.0104		
Fabrics x Treatments	8	0.0752	0.0094	1.23
Within cell variation	15	0.1146	0.0076	
FILLING				
Fabrics	2	5.6814	2.8407	525.74**
Treatments	4	0.0705	0.0176	3.26
No softener vs. softeners	1	0.0484	0.0484	8.96**
Remainder	3	0.0221		
Fabrics x Treatments	8	0.1151	0.0144	2.66*
Within cell variation	15	0.0810	0.0054	

* Significant at .05.
** Significant at .01.

APPENDIX D

ANALYSIS OF VARIANCE TABLES FOR WRINKLE RECOVERY

TABLE XXXIV

ANALYSIS OF VARIANCE FOR WRINKLE RECOVERY BEFORE LAUNDERING

Source	Degrees of freedom	Sum of squares	Mean square	F value
Fabrics	2	27021.3330	13510.6670	1.50
Within cell variation	3	27024.8330	9008.2780	

* Significant at .05.
** Significant at .01.

APPENDIX D (Continued)

TABLE XXXV

ANALYSIS OF VARIANCE FOR WRINKLE RECOVERY
FIRST INTERVAL

Source	Degrees of freedom	Sum of squares	Mean square	F value
Fabrics	2	80407.3910	40203.6950	1634.32**
Treatments	4	119.8006	29.9501	1.22
No softener vs. Softeners	1	7.0083	7.0083	0.28
Remainder	3	112.7923		
Fabrics x Treatments	8	128.5744	16.0718	0.65
Within cell variation	15	368.9957	24.5997	

* Significant at .05.
** Significant at .01.

APPENDIX D (Continued)

TABLE XXXVI

ANALYSIS OF VARIANCE FOR WRINKLE RECOVERY
THIRD INTERVAL

Source	Degrees of freedom	Sum of squares	Mean square	F value
Fabrics	2	58131.2560	29065.6280	950.88**
Treatments	4	311.6608	77.9152	2.55
No softener vs. Softeners	1	213.3333	213.3333	6.98*
Remainder	3	98.3275		
Fabrics x Treatments	8	21474.8380	2684.3548	87.82**
Within cell variation	15	458.5075	30.5672	

* Significant at .05.
** Significant at .01.

APPENDIX D (Continued)

TABLE XXXVII

ANALYSIS OF VARIANCE FOR WRINKLE RECOVERY
SIXTH INTERVAL

Source	Degrees of freedom	Sum of squares	Mean square	F value
Fabrics	2	49041.2520	24520.6260	742.26**
Treatments	4	203.8384	50.9596	1.54
No softener vs. Softeners	1	43.2000	43.2000	1.31
Remainder	3	160.6384		
Fabrics x Treatments	8	22474.2890	2809.2861	85.00**
Within cell variation	15	495.5292	33.0353	

* Significant at .05.
** Significant at .01.

APPENDIX D (Continued)

TABLE XXXVIII

ANALYSIS OF VARIANCE FOR WRINKLE RECOVERY
TWELFTH INTERVAL

Source	Degrees of freedom	Sum of squares		Mean square	F value
Fabrics	2		51052.8760	25526.4380	968.16**
Treatments	4		188.3316	47.0829	1.78
No softener vs. Softeners	1	151.8750		151.8750	5.76*
Remainder	3	36.4566			
Fabrics x Treatments	8		81.4438	10.1805	0.39
Within cell variation	15		395.4887	26.3659	

* Significant at .05.
** Significant at .01.

APPENDIX D (Continued)

TABLE XXXIX

ANALYSIS OF VARIANCE FOR WRINKLE RECOVERY
TWENTY-FOURTH INTERVAL

Source	Degrees of freedom	Sum of squares	Mean square	F value
Fabrics	2	47984.0470	23992.0230	1869.24**
Treatments	4	389.5378	97.3844	7.59**
No softener vs. Softeners	1	357.0750	357.0750	27.82**
Remainder	3	32.4628		
Fabrics x Treatments	8	11325.8360	1415.7295	110.30**
Within cell variation	15	192.5278	12.8352	

* Significant at .05.
** Significant at .01.

APPENDIX E

ANALYSIS OF VARIANCE TABLES FOR STIFFNESS

TABLE XL

ANALYSIS OF VARIANCE FOR STIFFNESS BEFORE LAUNDERING

Source	Degrees of freedom	Sum of squares	Mean square	F value
WARP				
Fabrics	2	0.1808	0.0904	2.92
Within cell variation	3	0.0929	0.0310	
FILLING				
Fabrics	2	0.1973	0.0968	1.36
Within cell variation	3	0.2127	0.0709	

* Significant at .05.
** Significant at .01.

APPENDIX E (Continued)

TABLE XLI

ANALYSIS OF VARIANCE FOR STIFFNESS
FIRST INTERVAL

Source	Degrees of freedom		Sum of squares		Mean square	F value
WARP						
Fabrics		2		0.1927	0.0963	22.78**
Treatments		4		0.0380	0.0095	2.25
No softener vs. Softeners	1		0.0003		0.0003	0.07
Remainder	3		0.0377			
Fabrics x Treatments		8		0.0163	0.0020	0.48
Within cell variation		15		0.0634	0.0042	
FILLING						
Fabrics		2		0.0391	0.0196	6.91*
Treatments		4		0.0174	0.0043	1.53
No softeners vs. Softeners	1		0.0056		0.0056	2.00
Remainder	3		0.0118			
Fabrics x Treatments		8		0.0071	0.0009	0.31
Within cell variation		15		0.0425	0.0028	

* Significant at .05.
** Significant at .01.

APPENDIX E (Continued)

TABLE XLII

ANALYSIS OF VARIANCE FOR STIFFNESS
THIRD INTERVAL

Source	Degrees of freedom		Sum of squares		Mean square	F value
WARP						
Fabrics		2		0.1809	0.0905	79.12**
Treatments		4		0.0194	0.0048	4.24*
No softener vs. Softeners	1		0.0175		0.0175	15.91**
Remainder	3		0.0019			
Fabrics x Treatments		8		0.0079	0.0010	0.87
Within cell variation		15		0.0171	0.0011	
FILLING						
Fabrics		2		0.1022	0.0511	79.05**
Treatments		4		0.0062	0.0016	2.40
No softeners vs. Softeners	1		0.0022		0.0022	3.67
Remainder	3		0.0042			
Fabrics x Treatments		8		0.0150	0.0019	2.90*
Within cell variation		15		0.0097	0.0006	

* Significant at .05.
** Significant at .01.

APPENDIX E (Continued)

TABLE XLIII

ANALYSIS OF VARIANCE FOR STIFFNESS
SIXTH INTERVAL

Source	Degrees of freedom		Sum of squares		Mean square	F value
WARP						
Fabrics		2		0.0417	0.0208	50.02**
Treatments		4		0.0070	0.0018	4.21*
No softener vs. Softeners	1		0.0013		0.0013	3.25
Remainder	3		0.0057			
Fabrics x Treatments		8		0.0059	0.0007	1.78
Within cell variation		15		0.0062	0.0004	
FILLING						
Fabrics		2		0.0021	0.0011	3.23
Treatments		4		0.0034	0.0008	2.67
No softener vs. Softeners	1		0.0008		0.0008	2.67
Remainder	3		0.0026			
Fabrics x Treatments		8		0.0046	0.0006	1.77
Within cell variation		15		0.0049	0.0003	

* Significant at .05.
** Significant at .01.

APPENDIX E (Continued)

TABLE XLIV

ANALYSIS OF VARIANCE FOR STIFFNESS
TWELFTH INTERVAL

Source	Degrees of freedom		Sum of squares		Mean square	F value
WARP						
Fabrics		2		0.0190	0.0095	41.82**
Treatments		4		0.0009	0.0002	0.98
No softener vs. Softeners	1		0.0006		0.0006	3.00
Remainder	3		0.0003			
Fabrics x Treatments		8		0.0029	0.0004	1.58
Within cell variation		15		0.0034	0.0002	
FILLING						
Fabrics		2		0.0088	0.0044	13.97**
Treatments		4		0.0021	0.0005	1.69
No softener vs. Softeners	1		0.0014		0.0014	4.67*
Remainder	3		0.0007			
Fabrics x Treatments		8		0.0096	0.0012	3.77*
Within cell variation		15		0.0048	0.0003	

* Significant at .05.
** Significant at .01.

APPENDIX E (Continued)

TABLE XLV

ANALYSIS OF VARIANCE FOR STIFFNESS
TWENTY-FOURTH INTERVAL

Source	Degrees of freedom	Sum of squares		Mean square	F value
WARP					
Fabrics	2		0.0023	0.0012	2.44
Treatments	4		0.0097	0.0024	5.04*
No softener vs. Softeners	1	0.0087		0.0087	17.40**
Remainder	3	0.0010			
Fabrics x Treatments	8		0.0073	0.0009	1.90
Within cell variation	15		0.0072	0.0005	
FILLING					
Fabrics	2		0.0051	0.0025	5.16*
Treatments	4		0.0062	0.0015	3.14
No softener vs. Softeners	1	0.0049		0.0049	9.80**
Remainder	3	0.0013			
Fabrics x Treatments	8		0.0093	0.0012	2.36
Within cell variation	15		0.0074	0.0005	

* Significant at .05.
** Significant at .01.

APPENDIX F

ANALYSIS OF VARIANCE FOR SURFACE APPEARANCE RATINGS

TABLE XLVI

ANALYSIS OF VARIANCE FOR SURFACE APPEARANCE RATINGS BEFORE LAUNDERING

Source	Degrees of freedom	Sum of squares	Mean square	F value
Fabrics	2	0.1415	0.0708	2.62
Treatments	4	0.0337	0.0084	0.31
No softener vs. Softeners	1	0.0234	0.0234	0.87
Remainder	3	0.0103		
Judges	2	0.6615	0.3308	12.25
Fabrics x treatments	8	0.2996	0.0374	1.39
Fabrics x judges	4	0.2332	0.0583	2.12
Treatments x judges	8	0.0796	0.0099	0.37
Fabrics x treatments x judges	16	3.2032	0.2002	7.41**
Within cell variation	45	1.2150	0.0270	

* Significant at .05.
** Significant at .01.

APPENDIX F (Continued)

TABLE XLVII

ANALYSIS OF VARIANCE FOR SURFACE APPEARANCE RATINGS
FIRST INTERVAL

Source	Degrees of freedom		Sum of squares		Mean square	F value
Fabrics		2		111.5342	55.7671	668.31**
Treatments		4		1.2173	0.3043	3.65*
No softener vs. Softeners	1		0.1308		0.1308	1.57
Remainder	3		1.0865			
Judges		2		15.7829	7.8914	94.57**
Fabrics x treatments		8		0.9913	0.1239	1.48
Fabrics x judges		4		0.7571	0.1893	2.27
Treatments x judges		8		1.0626	0.1328	1.59
Fabrics x treatments x judges		16		134.6612	8.4163	100.91**
Within cell variation		45		3.7550	0.0834	

* Significant at .05.
** Significant at ,01.

APPENDIX F (Continued)

TABLE XLVIII

ANALYSIS OF VARIANCE FOR SURFACE APPEARANCE RATINGS
THIRD INTERVAL

Source	Degrees of freedom	Sum of squares	Mean square	F value
Fabrics	2	130.5496	65.2748	1574.99**
Treatments	4	0.0773	0.0193	0.47
No softener vs. Softeners	1	0.0284	0.0284	0.68
Remainder	3	0.0489		
Judges	2	14.8276	7.4138	178.88**
Fabrics x treatments	8	0.8360	0.1045	2.52*
Fabrics x judges	4	1.3773	0.3443	8.32**
Treatments x judges	8	0.2380	0.0297	0.72
Fabrics x treatments x judges	16	149.7445	9.3590	226.06**
Within cell variation	45	1.8650	0.0414	

* Significant at .05.
** Significant at .01.

APPENDIX F (Continued)

TABLE XLIX

ANALYSIS OF VARIANCE FOR SURFACE APPEARANCE RATINGS
SIXTH INTERVAL

Source	Degrees of freedom	Sum of squares	Mean square	F value
Fabrics	2	135.6296	67.8148	2172.00**
Treatments	4	1.6138	0.4034	12.92**
No softener vs. Softeners	1	0.1156	0.1156	3.71
Remainder	3	1.4982		
Judges	2	8.1929	4.0964	131.20**
Fabrics x treatments	8	0.6882	0.0860	2.76*
Fabrics x judges	4	0.5051	0.1263	4.05**
Treatments x judges	8	1.6715	0.2089	6.69**
Fabrics x treatments x judges	16	150.9366	9.4335	302.36**
Within cell variation	45	1.4050	0.0312	

* Significant at .05.
** Significant at .01.

APPENDIX F (Continued)

TABLE L

ANALYSIS OF VARIANCE FOR SURFACE APPEARANCE RATINGS
TWELFTH INTERVAL

Source	Degrees of freedom	Sum of squares	Mean square	F value
Fabrics	2	106.7540	53.3770	1301.88**
Treatments	4	0.7351	0.1838	4.48**
No softener vs. Softeners	1	0.0014	0.0014	0.03
Remainder	3	0.7337		
Judges	2	27.7726	13.8863	338.69**
Fabrics x treatments	8	1.0449	0.1306	3.18**
Fabrics x judges	4	2.1454	0.5364	12.94**
Treatments x judges	8	0.3129	0.0391	0.95
Fabrics x treatments x judges	16	141.0890	8.8181	215.08**
Within cell variation	45	1.8450	0.0410	

* Significant at .05.
** Significant at .01.

APPENDIX F (Continued)

TABLE LI

ANALYSIS OF VARIANCE FOR SURFACE APPEARANCE RATINGS
TWENTY-FOURTH INTERVAL

Source	Degrees of freedom	Sum of squares		Mean square	F value
Fabrics	2		104.0107	52.0053	1560.16**
Treatments	4		0.4700	0.1175	3.52*
No softener vs. Softeners	1	0.0062		0.0062	0.19
Remainder	3	0.4638			
Judges	2		27.7527	13.8763	416.29**
Fabrics x treatments	8		0.2427	0.0303	0.91
Fabrics x judges	4		2.3186	0.5796	17.41**
Treatments x judges	8		0.7807	0.0976	2.93**
Fabrics x treatments x judges	16		138.1400	8.6338	259.27**
Within cell variation	45		1.5000	0.0333	

* Significant at .05.
** Significant at .01.

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This thesis was typed by

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